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STUDIES ON THE LIFE HISTORY OF HALIPEGUS OCCIDUALIS STAFFORD, 1905

WENDELL H. KRULL

Introduction

Halipegus occidualis Stafford, 1905, has been taken in the vicinity of Beltsville, Maryland, in the green frog, *Rana clamitans*. The fluke has been reared experimentally in this host by feeding the frogs with metacercariae collected from naturally infected dragonflies, *Libellula incesta*, identified by Mr. D. J. Borror of Ohio State University.

The eggs of the fluke *Halipegus occidualis* have been used to infect snails, *Helisoma antrosa*, identified by Mr. Wm. B. Marshall of the U. S. National Museum, which were raised from eggs under controlled conditions in the laboratory. The cercariae from one of these snails, as well as from naturally infected snails, have been used to infect *Cyclops (Acanthocyclops) vernalis* Fischer and *C. (A.) serrulatus* Fischer, identified by Dr. Chas. B. Wilson of Westfield, Mass. Dragonflies and damselflies have not been used in infection experiments. However, since the metacercariae of *Halipegus occidualis* have been found in dragonflies, and those of a related species have been found in damselflies, it is assumed that these insects become infected while they are nymphs by eating the infected cyclops.

Since the description of *Halipegus occidualis* given by Stafford, (1905), is relatively incomplete, the writer has considered it advisable to give a redescription of this fluke, which, with the description of the larval stages and experiments to determine the now known parts of the life history, are presented in the following pages. The present paper supplements an abstract given by Krull (1933).

Description of the Life History Stages

Sporocyst.—Daughter sporocyst vermiform (Figs. 3, 4), wider and usually bluntly rounded at germinal end, attenuated at opposite end, degree of attenuation varying with state of contraction of sporocyst. Three sporocysts which were filled with larvae were 660μ to 1.1 mm. (average 975μ) long by 140μ to 210μ (average 173μ) wide, when killed in corrosive fixative, and measured in 70 per cent alcohol. Four sporocysts which had lost most of

their larvae were 1.2 mm. to 1.8 mm. (average 1.4 mm.) long by 105μ to 115μ (average 110μ) wide, when killed in an extended condition and measured when stained and mounted. A pair of flame cells has been observed in the mid-body region. The largest larva observed in a sporocyst resembled a young redia in shape and was 330μ long by 60μ wide when stained and mounted.

Living sporocysts are active, may elongate and become very thin, and then, when observed under low magnification, superficially resemble nematodes in their shape and actions. By their activities, the sporocysts may be differentiated under a dissecting microscope from the rediae which are thicker, show more limited powers of contraction, and usually have dark food granules in the digestive tract. These granules are absent in the sporocyst.

Redia.—Redia (Figs. 5, 6, 7) elongated, anterior end usually bluntly rounded, wider than posterior end; body tapering toward pointed posterior end, devoid of appendages, and having a maximum length of 3.5 mm. Redia less active than sporocyst, pigmented, the color ranging from yellow to bright orange; pigmentation more pronounced in natural than in experimental infections. In redia immediately after being recovered from a snail, pharnyx typically pear-shaped, subsequently becoming oval or ovate. Intestine broad and short, only a small fraction of the body length in large specimens, usually filled with granules having a brown or black color. Redia sometimes containing more than 100 cercariae, of which 20 or 30 may be fully grown.

The rediae, upon being separated from the sporocyst, may be exceedingly small, as shown subsequently in the discussion of experimental infestations. The following measurements were secured from rediae which were actively shedding cercariae:

Five specimens relaxed in water were 3.0 mm. to 3.5 mm. long; pharynges averaged 69μ long by 59μ wide. Three specimens, moderately contracted in 0.7 per cent saline solution, averaged 1.6 mm. long by 220μ wide. Immediately after removal from the snail, 6 specimens, when measured under slight pressure, averaged 691μ long by 138μ wide. Eight stained and mounted specimens from an experimental infestation, the snail having shed cercariae for approximately a month, were 600μ to 840μ (average 695μ) long by 85μ to 140μ (average 116μ) wide; pharynges 42μ to 48μ (average 45μ) long by 28μ to 34μ (average 31μ)wide. The above measurements show that rediae which are shedding cercariae may vary considerably in size. Some of the variation may be due to contraction following fixation, imbibition of fluids, pressure of cover slip, etc.

Figure 7 represents a redia which was drawn after being in saline several hours, and which appears to be abnormal in respect to the distended cystic tails which surround the bodies of cercariae. It seems, after the examination of the rediae from a number of snails which were shedding cercariae by the hundreds daily, that the cystic tails are normally not distended during the time the cercariae are in the redia. However, the cystic tails of the cercariae while in the redia sometimes become distended in a couple of minutes after the

rediae are released from the snail into saline solution or water. The cystoid cercariae become distended and appear normal if dissected out of the redia. No birth pore has been observed in the redia, and no cercariae have been observed to escape, even though the cysts of the cercariae become distended and the rediae are filled to capacity. However, it appears that the cercariae leave the redia before their cystic tails become distended, and it seems highly probable that the cercariae even leave the snail host while in this condition.

The redia of *H. occidualis* is quite similar to that of *C. projecta* described by Willey (1930), except for the relative size, as indicated in his figure, of the pharynx of the redia as compared with size of the contained cercariae; however, it is suspected that this is possibly an error in recording the observation, and the two species may be identical.

The pigmented condition of the redia seems to be universal for rediae producing this type of cercaria; the color having been mentioned by several authors, among them Wagener (1866) for *Cercaria cystophora*, Cort and Nichols (1920) for *C. californiensis*, and Willey, (1930) for *C. projecta*.

Cercaria.—Cystoid cercaria (Fig. 9) very small, with an appendage resembling a handle. Body completely surrounded by a cystic tail. Elongated cercaria body and delivery tube folded up in the double-walled transparent cyst, enveloped by a thin membrane which follows cyst wall rather closely on side opposite handle, with space between membrane and cyst wall increasing gradually towards region of handle. Cyst proper 72μ to 83μ (average 76μ) in diameter, cercaria chamber 48μ to 53μ (average 50μ) wide, greatest width, between cyst wall proper and outer membrane, 11μ to 13μ (average 12μ), handle 65μ to 88μ (average 76μ) long by 22μ to 24μ (average 23μ) wide. Delivery tube 420μ to 470μ (average 458μ) in length when discharged, but folded in a collapsed condition in the chamber containing cercaria body. Handle contains a finely granular core which is intimately connected with cercaria chamber. Distal part of handle provided externally with 4 to 6 (average 5) longitudinal ridges, making the end view appear like a flower (Fig. 10). A fine cellular net in which the cells appear as pentagons or hexagons may be observed in the cyst. A so-called excretory bulb, sometimes containing a few granules, is present near the handle between the cyst wall and enveloping membrane. Cercaria body (Fig. 11) elongated and subcylindrical, except for slight enlargement at posterior end, 145μ to 270μ (average 195μ) long by 45μ to 85μ (average 58μ) wide, extremities rounded, posterior one slightly indented. Cuticula 2μ thick, cuticular roughenings, suggestive of spines, at anterior end extending posteriorly to level of anterior border of oral sucker. Oral sucker, 26μ to 43μ (average 33μ) in diameter, subterminal and ventral. Acetabulum, 22μ to 53μ (average 39μ) in diameter, situated at beginning of posterior third of body. Pharynx 16μ to 23μ (average 19μ) wide, fitted into the oral sucker posteriorly. Esophagus long, narrow, bifurcating and forming narrow ceca in which lumina are appearing, extending to near posterior end of body. Excretory bladder small, at posterior end of body, surrounded by numerous elongated, non-granular cells, the nuclei being 2.5μ in diameter. Bladder receiving anteriorly a median excretory vessel,

this bifurcating and forming a pair of lateral ducts which run anteriorly; in immature cercariae while still in rediae, these ducts may be traced anteriorly to the level of the oral sucker, dorsal to which they unite. Four pairs of flame cells (Fig. 11) have been observed. Excretory bladder opening to exterior by a median pore at posterior end of body. Large nuclei are conspicuous throughout the body of cercaria, and the relatively undifferentiated condition of the cercaria is noticeable.

The cercaria bodies from which the above measurements were obtained, were released from the cysts by touching their handles with a teasing needle as described by Krull (1933), this act supplying the necessary stimulus. The cercariae were measured in the living condition under slight pressure. In addition to the measurements already given, the following were secured from 4 specimens fixed in 10 per cent formalin: Cercaria body 125μ to 205μ (average 173μ) long by 33μ to 40μ (average 37μ) wide. This variation in length, due to state of contraction, existed also in cercariae bodies which were stained and mounted.

Immediately after the cercaria body escapes from the cyst there is a slight constriction (Fig. 13) in the acetabular region, which constriction disappears as the cercaria contracts. The cells surrounding the bladder are difficult to distinguish, and may be more easily seen when the living cercaria body is stained slightly with brilliant cresyl blue. The cercaria bodies may show slight superficial enlargements; sometimes these enlargements present a symmetrical appearance and appear as appendages. In several cases a median thickening was observed posterior to the acetabulum, which thickening was thought to be a remnant of a connection between the cercaria and the cyst; however, no such connection was apparent in any of the many cercariae of all ages which were studied. The significance of these enlargements was not determined.

The cercaria belongs to the small group of cercariae known as the Cystophorous Cercariae. The group has recently been reviewed by Willey (1930) who described *Cercaria projecta* Willey from *Helisoma antrosa*. Thomas (1932) has subsequently added *Cercaria sphaerula* from *Helisoma trivolvis*. The cercaria of *H. occidualis* is very similar to the two above-mentioned cercariae and these three cercariae may be very easily distinguished from the rest of the group either by the cyst appendages or the very different structure of the cercaria body. The cercaria of *H. occidualis* may be distinguished from *Cercaria sphaerula* by its smaller size and by the larger size of the cercaria body and its suckers, and from *C. projecta* by the presence of cuticular projections at the anterior end of the body, the larger size of the cercaria body and suckers, longer ceca, the apparent difference in excretory systems, the apparent absence of a connection between the excretory system and the tail structures, larger cyst, number of ridges on the handle of the cyst, longer length of delivery tube (referred to as the excretory projection by some writers, including Willey), absence of attachment of oral sucker to base of coiled delivery tube, and absence of uniform coiling of cercaria body in the cyst. The writer has been unable to find connections, except at the posterior end, between the cercaria body and the tail structure as described by Willey for *Cercaria pro-*

jecta. However, there may be a connection between the extra-cercarial portions, the excretory system and the so-called excretory bulb, but this also was not observed.

In the early development of the cercaria, the highly specialized tail and its appendages and the cercaria body proper are separated by a constriction. The delivery tube, considered as an appendage of the highly specialized tail, is differentiated at about the same time that the constriction between body and tail appears. In the subsequent development of the cercaria the handle is differentiated from the sacculate portion of the tail. The opening of the sacculate part during development is on the side opposite the handle, and from this opening project the developing delivery tube and cercaria body. At a certain stage in development of the delivery tube, which is entirely cellular, the terminal end is large and Indian-club-shaped, it being terminated by a large cell having a nucleus containing a large nucleolus with a more proximal spherical mass of cells with smaller nuclei without visible nucleoli. When the tube has completed its development, the tip resembles a spore with a highly refractile wall followed by a more proximal thick-walled tubular portion, the lumen of which is lined with large, highly refractile granules. The remaining undifferentiated portion of the tube consists of a linear series of cells in which the long axis of the cell is at right angles to the tube during development (Fig. 8), but when growth has been completed and the cells have elongated, the long axis is parallel to the long axis of the tube. The cells are destroyed and the granules at the distal end appear on the outside of the tube when the cercaria is discharged because the tube is then everted (Fig. 12). The attachment of the tube is at the base of the handle inside of the cyst, and during development is independent of the broad attachment of the cercaria body. After the cercaria body, which at this time is broad and short, and the delivery tube, in a collapsed condition, have been enclosed by the cyst, the cyst is closed up completely while the handle on the opposite side remains in a more or less collapsed condition. In this condition the cercaria apparently makes its escape from the redia and perhaps from the snail, as previously stated. If such a cercaria is exposed to water or 0.7 to 0.4 per cent saline solution, it apparently imbibes the liquid, and the active unattached cercaria body in the cyst increases in length, folds up and, apparently due to extreme pressure, loses all its powers of movement. The inner and outer cyst walls become separated while the cercaria body is taking up its permanent position; the outer, thinner, supernumerary membrane around the cyst proper becomes separated from it, and the handle becomes rigid; thus, the cercaria has reached its final form.

After leaving the snail, the cercaria sinks to the bottom of the container where it rests in such a position that the axis of the handle is at an obtuse angle, rarely at right angles, with the substratum. Every vibration or disturbance of the water changes this angle. Examination of cercariae kept in clean water in covered stender dishes at room temperature, showed that the maximum life of the cercaria under such conditions was not more than 2 weeks. Comparatively few cercariae will discharge the cercaria bodies, when

stimulated, after the second day. Willey (1930) reported that under similar conditions, *Cercaria projecta*, a related species, lived longer than 6 weeks.

The outline of the cercaria body of *H. occidualis* is very distinct in cercariae shortly after they escape from the snail. The cercaria body, after a day or so, however, becomes progressively more crowded in the cyst and finally the outline of the folded body is obliterated. Subsequently, after a variable period of time, the cercaria body becomes opaque, a condition indicating its death. Consequently, it is the opinion of the writer that the pressure in the cyst, due to imbibition of water, increases after the escape of the cercaria from the snail, and that this pressure is largely responsible for the death of the cercaria.

Metacercaria.—Body (Fig. 14) 478μ long by 182μ wide. Cuticula thick and smooth. Oral sucker subventral and subterminal, 82μ long by 84μ wide. Prepharynx not evident. Pharynx 38μ long by 36μ wide, opening into esophagus, the latter bifurcating immediately to form voluminous ceca extending to near posterior end of body. Acetabulum 154μ long by 170μ wide, in posterior half of body, its anterior border equatorial. Testes extracecal at posterior border of acetabulum, right testis slightly in advance of left. Ovary intercecal, submedian, post-testicular, smaller than testes. Primordia of Mehlis' gland and uterus evident. Excretory system consisting of a pair of lateral ducts united anteriorly by a commissure dorsal to oral sucker and anterior to pharynx; ducts also uniting posterior to acetabulum forming a median vessel discharging at excretory pore situated at posterior end of body.

The above description is based on a single stained and mounted specimen obtained from a naturally infected dragonfly, *Libellula incesta*, taken in the region of Beltsville, Maryland.

Adult.—Body (Fig. 1) elongate, 5.8 mm. long by 1.7 mm. wide; greatest width in testicular zone. Cuticula 20μ thick, spineless. Oral sucker subterminal, 470μ in diameter. Prepharynx absent; pharynx 197μ long by 154μ wide. Esophagus very short. Ceca rather narrow and sinuous, extending dorsal to other organs, to near posterior end of body. Acetabulum very muscular, 714μ in diameter, its posterior border being equatorial. Testes extracecal, subspherical to oval, subequal, averaging 782μ long by 590μ wide, with long axes parallel to long axis of body; relative position to each other and the acetabulum somewhat variable, usually lateral, oblique, not in contact; anterior testis somewhat posterior to posterior border of acetabulum. Seminal receptacle elongated and broad, extending more or less dorsoventrally, narrowing and surrounded by prostate gland cells near genital pore. Ovary suboval, average size 384μ long by 307μ wide, intercecal, and nearer median line than testes, a short distance posterior to posterior testis; long axis usually at right angles to long axis of body. Oviduct joining with Laurer's canal and then, after receiving common vitelline duct, continuing as the oötype, this latter surrounded by an exceedingly well developed Mehlis' gland. Proximal end of Laurer's canal expanded, probably functioning as a seminal receptacle. Uterus filling all available space from bifurcation of intestine to vitellaria, the

folds for the most part being transverse. Genital pore ventral and median, near posterior border of oral sucker. Vitelline follicles round to oval, 240μ to 330μ in mean diameter, largest follicles approaching ovary in size, in two grape-like clusters at extreme posterior end of body; follicles in each group varying from 4 to 6, the number, apparently, never being the same on both sides. Vitelline ducts originating from follicles, uniting, and forming a right and left vitelline duct, the two ducts joining and forming a short common vitelline duct. Lateral excretory vessels uniting dorsal to oral sucker and joining again posterior to actabulum, forming a median vessel discharging at terminal excretory pore at posterior end of body. Eggs (Fig. 2) yellow, ovate, broad end operculate, the non-operculate end prolonged into a long filament narrowing gradually for its entire length to a fine tip; eggs from a preserved fluke averaging 50μ long by 21μ wide, measured without filament; eggs from living fluke averaging 61μ long by 26μ wide, filament 160μ to 200μ long. Miraciduim present in egg when deposited.

The above description is based on five large specimens collected in August from under the tongue of a large green frog, *R. clamitans,* collected near Beltsville, Maryland. Three of the flukes were relaxed in water before being killed in corrosive-acetic fixative, and the other two were killed immediately under slight pressure, these being poor specimens because of contraction and the presence of innumerable eggs obliterating some of the organs. One of the relaxed specimens was 6.5 mm. long by 2.0 mm. wide, while each of the other two was 5.5 mm. long by 1.5 mm. wide. The oral sucker in the five flukes varied from 380μ to 550μ in diameter, and the actabulum from 590μ to 830μ. The pharynx varied from 140μ to 172μ in width. The anterior testis varied from 490μ to 880μ long by 550μ to 710μ wide, and the posterior from 670μ to 1.04 mm. long by 475 to 670μ wide. The right testis was anterior to the left in two of the five specimens; in one specimen the testes were nearly at the same level, and in another the posterior border of the acetabulum and the anterior border of the anterior testis were at the same level. The ovary varied from 375μ to 400μ long by 290μ to 325μ in width. One specimen had four vitelline follicles on the right and six on the left side, another had this arrangement reversed; two had five follicles on the right and four on the left, and the remaining one had this arrangement reversed. The eggs in preserved specimens varied from 41μ to 55μ long by 20μ to 24μ in 27 eggs measured; the filaments on the eggs appeared to be at least as long as or longer than the egg.

Figure 15 represents a fluke shortly after maturity, and was obtained from an experimental infection discussed in a subsequent section.

Stafford's description of the parasite which he collected from "*Rana clamata* Daud." and *R. catesbeiana* differs slightly from the above redescription. According to Stafford's description, there are five vitelline follicles on one side and four on the other. He stated that the filament on the egg appeared to be shorter than the egg, "but towards the end it becomes very thin and bent or twisted so that it is hard to get a straight measurement." He

stated, furthermore, that the eggs were generally 63μ by 18μ, the filament 56μ. These measurements of the egg proper correspond to measurements of the eggs from living specimens as given in the present paper. Nickerson (1898) found this parasite in frogs, "*Rana clamata,*" in the vicinity of Boston. He reported variations in the position of the testes, and stated that in some the testes were at the same level. The vitellaria, according to Nickerson, consisted of a single mass of nine nearly spherical masses in the posterior end of the body. The filament on the egg was described as being as long as 1 to 1.5 times the length of the egg.

Remarks concerning Halipegus sp. from Michigan

As previously stated by Krull (1933), metacercariae similar to those of *H. occidualis* have been collected from the damselfly, *Lestes rectangularis*, identified by Dr. C. H. Kennedy of Ohio State University, in the Douglas Lake region of Michigan. These metacercariae are somewhat larger than those of *H. occidualis*, and are either the metacercariae of the same species or of a very closely related species of *Halipegus*. One of the larger stained and mounted specimens is 655μ long by 260μ wide; oral sucker 94μ long by 96μ wide; pharynx 46μ long by 52μ wide; and acetabulum 194μ in diameter.

In June, 1929, the writer collected a single specimen of *Halipegus* sp. from a green frog, *Rana clamitans*, collected in the vicinity of Ann Arbor, Michigan, which, on the basis of a single specimen, can not be referred with certainty to the species *H. occidualis*. The specimen, which was relaxed, stained and mounted in the same way as those of *H. occidualis* used as a basis for the description given in this paper, is 6 mm. long by 1.75 mm. wide; oral sucker 480μ in diameter, pharynx 188μ long by 145μ wide; acetabulum 700μ long by 720μ wide; ovary 445μ long by 310μ wide; anterior testis about the same size as ovary, posterior testis 530μ long by 360μ wide; four vitelline follicles on one side and five on the other, four eggs averaged 52μ long by 23μ wide.

A comparison of the measurements of this specimen with those of *H. occidualis* shows a difference in the relative size of acetabulum, testes and ovary of the two flukes; there is also an actual appreciable difference in the size of their sex organs. It appears probable, therefore, if more than one species of *Halipegus* exists in the North American frogs, the specific differences in the flukes will be very minute and it may be necessary to depend on such characters as the relative size of organs in order to distinguish the species. However, it is possible that the smaller organs are the result of a senile condition, since the specimen was taken in the late spring and was, no doubt, an infection acquired by the frog during the previous season. Consequently, it seems advisable to consider the above specimen a *species inquirenda* until further data are available.

Experiments

Information Relative to Experiment Animals

Hosts.—The snails, *Helisoma antrosa,* which were used in the infection experiments were raised from eggs in the laboratory. The parent snails were collected in a local pond during the summer of 1932, and kept in aquaria until they laid eggs the following spring. After a number of egg masses had been deposited the parent snails were removed and the eggs were left to hatch. When the eggs hatched in February and March, 1933, the young snails were transferred to suitable aquaria containing filtered water and used as desired when the young snails had attained sufficient size. Since these snails hatched and were kept under conditions which precluded any possibility of infection, no control was considered necessary, especially since snails from the above laboratory stock used in other experiments were all negative for infestations with *H. occidualis.*

Cyclops sp. used in the experiment were laboratory raised and free from infection. The frogs, *Rana clamitans,* used in the experiments were collected as tadpoles during May and June in a small pond containing acid water on the Zoological Division Field Station, Beltsville, Maryland. The tadpoles transformed during June in the laboratory and subsequently the frogs were kept out of doors in wooden pens which were covered with metal lath. The frogs lived on flies attracted by decaying meat in the pens. As a control, 45 of these frogs were examined in September after having been in the pens all summer; all were negative for all kinds of flukes. Since *H. occidualis* occurs normally in the mouth of the frog, the frogs used in the experiment were examined at the time they were subjected to infection and found to be negative at that time. The parasite eggs used as a source of miracidia in the infection experiment were discharged by the specimens on which the description of the adult is based.

Infection experiment involving first intermediate host. Six snails, *Helisoma antrosa,* one-fourth to one-third grown, were subjected to infection by putting them in a small covered stender dish which had been supplied with filtered water, calcium carbonate and eggs of *H. occidualis.* Twelve hours later the snails were transferred to a larger aquarium. The fecal cylinders of calcium carbonate deposited by the snails were examined, and of the parasite eggs present, the majority were represented by shells only, indicating that the miracidia had escaped. It had been previously determined that eggs would not hatch when they were left standing in water, and this and the above observation indicate that the eggs do not hatch until eaten by the snail.

The first snail in this experiment died 13 days after being subjected to infection. When the dead snail was discovered the small sporocysts with which it was infected were dead and the snail was disintegrating. Another snail, found dying 17 days after being subjected to infection, was examined and a very large number of small sporocysts were recovered from the proximal end of the digestive gland. The smallest remaining snail, 3.75 mm. in diameter,

died 29 days after being subjected to infection and from it 62 sporocysts were recovered. The sporocysts were crowded with germ balls, some of which had begun to elongate. Another snail, found dying 49 days after being subjected to infection, contained several sporocysts, some of maximum size and numerous smaller ones; in this snail the digestive gland was almost entirely destroyed. In addition to the sporocysts, there were hundreds of very small rediae (Fig. 5) not over 250μ long, which, under low magnification, were seen to have their digestive systems filled with liver material, and which resembled short-tailed cercariae with eyespots; when killed in formalin and then stained and mounted these were 100μ to 200μ long. Another snail died 76 days after being subjected to infection. The digestive gland of this snail had been entirely destroyed and replaced by a mass of larvae; about 30 fully grown sporocysts and hundreds of starving rediae containing developing cercariae were recovered. In the largest rediae, the cercaria bodies had become elongated but were not quite fully grown. The remaining snail, 94 days after being subjected to infection, shed a total of 31 cercariae and a day later shed 65 cercariae. In all of the cercariae shed during the first two days, the so-called handles were crippled. The snail was shedding normal cercariae, however, when tested again, 13 days later. The snail, now half grown, continued to shed cercariae for 13 more days before it died. When dissected this snail contained hundreds of rediae and a few sporocysts which were empty except for a few germ balls; such sporocysts were regarded as senile. Sporocysts have not been observed in naturally infected snails. Several naturally infected snails, which were shedding many cercariae, have been examined and no sporocysts were found; it appears, therefore, that the sporocysts usually disappear soon after the snails begin to shed cercariae. It is possible also that the few sporocysts present are overlooked in heavy natural infections because the sporocyst bears a remarkable resemblance, superficially, to the redia, especially if the redia is somewhat starved and the digestive system empty. Willey, who examined 70 snails which were actively shedding *Cercaria projecta*, a very closely related species, found no sporocysts.

Infection experiments involving Cyclops. The species of *Cyclops* which have been infected with *H. occidualis* include *Cyclops (Acanthocyclops) vernalis* Fischer, both development stages (copepodid larvae with only three pairs of legs) and adults, and *Cyclops (Eucyclops) serrulatus* Fischer, adults which were not fully grown. The species of *Cyclops* mentioned have been infected on repeated occasions by transferring them to aquaria containing cercariae alone or cercariae with actively shedding snails. However, only those experiments undertaken to determine definitely how cyclops become infected will be described.

In studying cyclops in the presence of cercariae some interesting observations were recorded. Both mature and young cyclops appear to be very fond of the cercariae, and the larger cyclops eat one cercaria after another, the cercaria body being discharged into the mouth of the cyclops by a manipulation of the handle, after which the cystoid portion is eaten. In a short time the intestine of the cyclops becomes distended with larvae, and it is not un-

common to find as many as 16 in the digestive system at one time. Occasionally a larva is missed by the cyclops; however, the larva which remains active on the bottom of the dish, is picked up later as soon as the cyclops is again in the vicinity of the larva. The further activities of the cercaria bodies in the intestines have been studied in mature as well as in immature cyclops, and in none have the larvae which have been swallowed been observed to penetrate the intestine of the cyclops even though the larvae continued to move around in the intestine.

In many cases the smaller cyclops eat the cercariae as above described, but occasionally when the cystoid cercaria is discharged into the mouth of the cyclops the latter makes a terrific spurt for a moment and lies motionless, with the appendages widely separated, as if dead, on the bottom of the container for as long as a minute in some cases. While it is in this condition a part of the delivery tube with the attached cyst of the cercaria usually projects from the mouth. The cyclops suddenly regains its equilibrium and appears normal except that it now contains an active larval fluke which is almost always in the body cavity and only occasionally in the intestine.

After repeated trials it was possible for the writer to bring the cyclops under observation with a compound microscope in as short a time as 20 seconds, after they were stunned by the discharging cercariae. In each case the cercaria body was found to be in the body cavity, sometimes being in the extreme posterior end of the body. Subsequent to these observations, corrosive-acetic fixative was added to a container the instant the cyclops was stunned by a cercaria. After a number of cyclops had been thus treated, they were dehydrated, embedded and sectioned serially. In several cyclops the larvae were definitely determined to be in the body cavity, and in one case the larva was located in the extreme posterior end of the body.

It is the opinion of the writer, therefore, that the elaborate appendages of the cercaria are not only for the purpose of attracting the cyclops but also for delivering the larva quickly and actively into the body cavity of the cyclops through the appendage which the writer terms the delivery tube. The very quick and forceful eversion of the delivery tube with its highly modified tip acts, apparently, as a dart and pierces the digestive tract of the host. The larva, passing through the tube immediately after the cercaria is discharged, is much compressed and elongated by the small tube, although the tube dilates considerably at the time. The granules on the outside of the modified portion of the tube, proximal to its tip, function possibly in securing the tube in the punctured digestive system during the passage of the cercaria into the body cavity. However, as determined from the sectioned material, it occasionally happens that the larva is discharged into the intestine.

It was previously stated by Krull (1933) that mature cyclops had not been infected but these experiments have shown that young adults may become infected. In this connection it may be noted that many large unidentified cyclops have been subjected to infection, and although they ate many of the cercariae, none became infected. This suggests that the longer appendages in

larger cyclops prevent the delivery tube from reaching its destination when discharged. Furthermore, it may be noted that the adults of *Cyclops (Acanthocyclops) vernalis* Fischer are small as compared with the adults of the other species, this small size, perhaps, being a factor favoring their chance of becoming infected. The largest number of larvae observed in the body cavity of a single cyclops was 16. Thomas (1932) states that he observed the ingestion of a similar cercaria, *Cercaria sphaerula*, by *Cyclops vulgaris*, and also observed the presence of larvae in the body cavity of that species; no details were given.

Dragonflies, *Libellula incesta* Hagen, have been found naturally infected with metacercariae of *H. occidualis*. No experiments have so far been conducted to determine the manner in which this insect becomes infected; however, it is possible that these dragonflies become infected as nymphs by eating infected cyclops. At any rate the dragonfly appears to serve as a third intermediate host.

Infection experiment involving definitive host. A metacercaria of *H. occidualis* obtained from the abdomen of the imago dragonfly, *Libellula incesta* Hagen, collected in August, was transferred to the mouth of a green frog, *Rana clamitans*. When the mouth of the frog was examined 22 days later, the fluke, similar in color to the tissues of the mouth of the frog, was located on the under side of the tongue at the junction of its base and the floor of the mouth. The fluke was removed and estimated as being about four times the size of the metacercaria; the sex organs as well as vitellaria were prominent in the fluke. After a casual examination the fluke was then transferred to the mouth of another green frog where it continued its growth. Thirty-four days after the fluke had been transferred to this second frog, a fecal sample was taken and found to contain two eggs of *H. occidualis*. It is quite probable that this fecal sample was taken shortly after the fluke began to shed eggs, since subsequent samples usually contained 40 to 60 eggs. The parasite continued to grow for about two months, and the change in size was noticeable from time to time on casual examination. The fluke was always observed to be under the tongue, and the color of the fluke became darker with age. The fluke at this time, March 3, 1934, is alive. Another green frog was given a metacercaria of *H. occidualis*, and 20 days later the fluke (Fig. 15) was recovered; two eggs were observed in the uterus.

The above experiment shows (1) that *Libellula incesta* is a final, apparently the third, intermediate host of *H. occidualis*, (2) that the growing parasite may be transferred from one definite host, *Rana clamitans*, to another, (3) that approximately 20 days are required for the parasite to reach maturity, and (4) that the parasite may require approximately three months to become fully grown in the definitive host when summer temperatures prevail.

Summary

The greater part of the life history of *Halipegus occidualis* has been determined by controlled experiments. The snail *Helisoma antrosa* and the dragonfly *Libellula incesta* were found to serve as intermediate hosts, and the frog *Rana clamitans* as a definitive experimental host. Crustaceans, *Cyclops (Acanthocyclops) vernalis* Fischer and *C. (A.) serrulatus* Fischer, have been infected experimentally and possibly serve as second intermediate hosts; whether dragonflies become infected by eating the infected cyclops has not been determined. The hosts, except for the cyclops, were found as natural hosts of *H. occidualis* in the vicinity of Beltsville, Maryland. A description of *H. occidualis*, as well as a description of the experiments involved in establishing the known part of the life history and the principal life history stages, has been given.

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PLATE 4

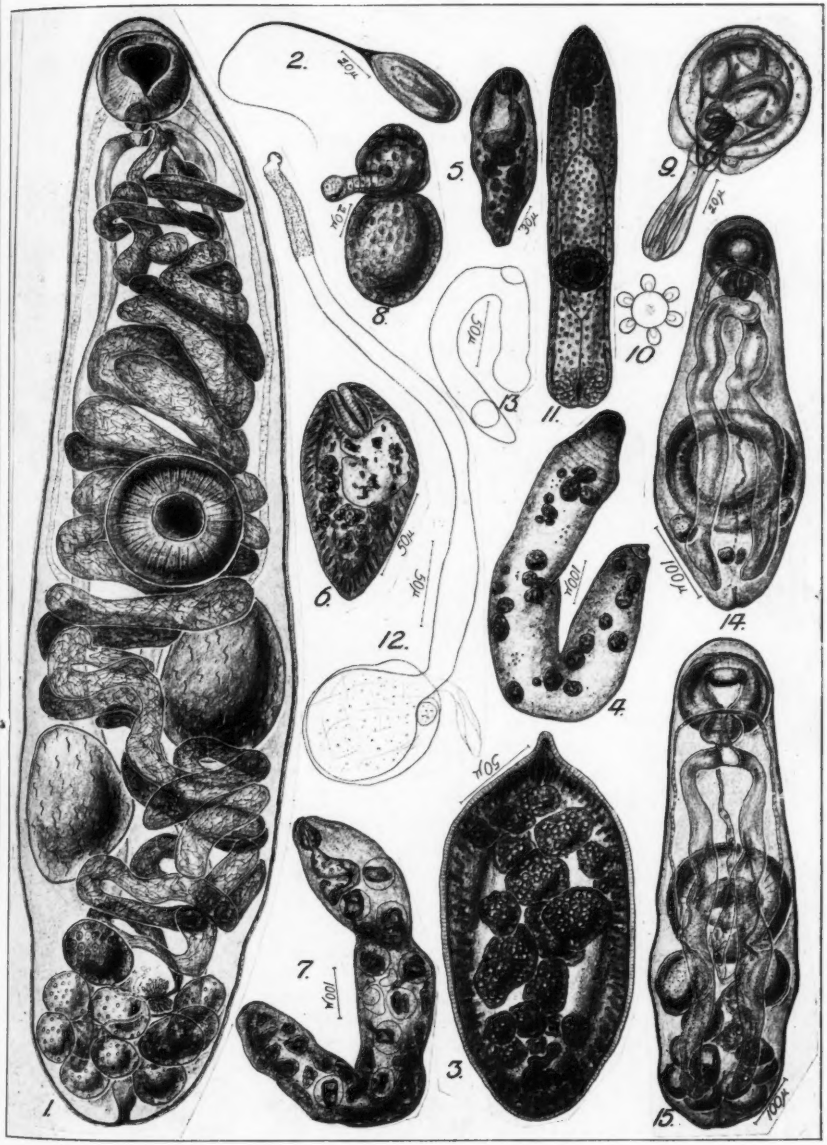
Halipegus occidualis Stafford, 1905

All figures drawn with the aid of a camera lucida. Figures 1, 3, 4, 6, 14 and 15 drawn from stained and mounted specimens, and figures 2, 5, 7, 8, 9, 10, 11 and 12 from living specimens.

FIGURES

1. Adult, ventral view; one of specimens used in the redescription.
2. Egg.
3. Young daughter sporocyst from an experimental infestation.
4. Senile daughter sporocyst from an experimental infestation.
5. Young redia from an experimental infestation.
6. Young redia from an experimental infestation.
7. Redia.
8. Developing cercaria.
9. Cercaria.
10. Handle of cercaria, end view, showing 6 fins.
11. Cercaria body, ventral view.
12. Cercaria appendages, after discharge of cercaria body.
13. Cercaria body, killed in 10 per cent formalin before it had contracted, immediately after discharge from cystoid tail.
14. Metacercaria, dorsal view.
15. Young fluke at the time of reaching maturity, dorsal view.

PLATE 4



ABNORMALITIES IN THE UTERINE YOUNG OF CAMPELOMA RUFUM, A FRESH-WATER SNAIL *

NORMAN T. MATTOX

In the study of our fresh-water snails, work on the developmental forms has been very incomplete. This is true of *Campeloma*, one of the genera of the family *Viviparidae* found in the eastern United States; and it is particularly true of the species *C. rufum* regarding the uterine development of which very little is known. In view of this fact a study of the uterine development especially of abnormal forms was undertaken.

All of the collections have been made at Homer Park, Illinois, in the Salt Fork branch of the Vermilion River, where *C. rufum* is the only species of *Campeloma* and where it occurs in relatively large numbers. During the period from September 1933 to May 1934, 274 individuals were collected in eight different samples, varying in number from 25 to 66 per sample.

The writer is indebted to Dr. H. J. Van Cleave, of the University of Illinois, whose helpful suggestions and encouragement have made this study possible. Likewise to Mr. Frank C. Baker, who determined the specimens, and to John Mizelle, William Van Deventer, and Philip Van Cleave who helped in the collection of materials.

Uterine Development.—The embryos of this species, as of all the Viviparidae, are developed within the uterus of the adult. The uterus is a thin-walled, membranous sac extending from the edge of the mantle posteriorly on the right dorsal side of the animal. It is terminated at the posterior end by the opening of the duct from the spermatheca, which receives the oviduct, about two-thirds the length of the body posteriorly. The anterior termination is marked by a distinct vaginal tube which is 3.2 mm. long in an adult with a shell 30 mm. in height. The vaginal tube is thick-walled and muscular, and discharges through a slight protuberance into the mantle cavity on the ventral surface of the mantle in close approximation to the anus.

The contents of the uterus at almost every season of the year vary from young veliger larvae to the shelled young. The average size of the young at the time of birth is approximately 3.5 mm. in height. The actual and relative numbers of young and eggs found within a single uterus vary a great deal. The variation seems not to be directly proportionate to the size of the adult, but is probably closely correlated.

Each developing egg is enveloped in a thin, transparent egg membrane, which has a stalk extending in a tail-like form hanging free in the uterine cavity (Fig. 2). It is worthy of note here that no mention of such an egg membrane stalk on the egg membrane of this species has been found in any of the available literature. However, Alonte (1930) notes such a develop-

* Contribution from the Zoological Laboratory of the University of Illinois, No. 460.

ment on the egg membrane of *Vivipara angularis*. Crabb (1931) also figured such a stalk on the egg membrane of *V. malleatus* and labeled it the "funiculus." The base of this stalk takes on a folded and twisted appearance resembling the neck of a twisted and tied sack. There is no connection of this stalk to any part of the uterus or to other egg membranes. This membrane is retained by the young until it is ready to be cast free from the vaginal tube, when by a series of extension of the operculum and the foot backward and the head forward it is torn free from the young snail and sloughed off over the shell.

When the uterine eggs are placed in water they rapidly become distended, increasing perceptibly in size and after a few minutes the membrane ruptures. This is explained by Crabb (1929) as being due to "the rapid imbibition of water by the egg." Fully formed young removed from the uterus have been kept alive in an aquarium for eight days. Crabb (1929) succeeded in rearing the young of *V. malleatus*, prematurely removed from the uterus, for a period of from eight to eleven months, but not to adult size. This demonstrates the ability of this snail to live after a premature birth.

The veliger embryos are embedded in albumen which serves as food for the developing embryo. These embryos are provided with minute cilia by which they swim freely within the albumen. When the shell is developed and the embryo is ready to be cast out the albumen is entirely consumed.

It was during the study of uterine forms that many abnormalities and monstrosities were observed. These abnormal forms were of such unusual development that it was thought that they deserved special study since very little attention has been given them in the literature. The following divisions of this paper will therefore be devoted to the description of these forms.

In the course of this study a number of interesting instances of reversal of symmetry have been observed. These are not treated here because a detailed study on the reversal of symmetry in *C. rufum* is being made by other workers in this laboratory.

Twinning.—There has been much discussion as to whether "twins" or "true tins" (Newman, 1923) really occur in the Mollusca. Newman (1923) states that true twins do not occur in the Mollusca because of the early determinate cleavage in its highest form. He states that in groups with strictly determined cleavage there is no twinning because twinning requires a totipotency of blastomeres or regions of the blastomeres.

Crabb and Crabb (1927) in their experimental work with the eggs of *Physa sayii, Lymnaea stagnalis appressa* and *L. palustris* containing more than one vitellus came to the conclusion that these are cases of polyvitelly and not true twins. This suggests that it is by sheer accident that eggs with more than one vitellus or embryo are produced. Crabb (1931) failed to support the possible monozygotic origin of two or more vitelli or embryos which had been found or produced in a single fresh-water snail egg. This author found polyvitelly in various snails: *Physa sayii, P. ancillaria, P. gyrina, Campeloma decisum, Viviparus malleatus, V. contectoides, Planorbis umbilicatellus, Lymnaea palustris* and *L. stagnalis appressa*. Crabb expressed his belief that there

is no hereditary factor in the production of such eggs. Winsor and Winsor (1932), however, in working with polyvitelline eggs of *Lymnaea columella* concluded that there is an expression of some hereditary factor in forms producing such eggs.

Hall (1925) reports finding embryonic individuals of the sessile tubiculous mollusc, *Serpuloides vermicularis*, in a twinned condition. These were cases in which apparently normal individuals were encased within a single membrane, but of sub-normal size. Similarly Pelseneer (1920) reports the finding quite commonly of twins, eggs with more than one embryo, in *Physa fontinalis* and more frequently in *Lymnaea stagnalis*. The examination of 205,590 eggs, by Pelseneer, revealed 326 with more than one embryo. Neither of these workers proved the twin theory and seemed unaware of the possibility of the phenomena of polyvitelly. This renders the validity of their discussions doubtful.

In the present study of *Campeloma rufum*, many membranes containing more than one embryo have been encountered. From Table 1 it is apparent that 2.7% of the total number of embryonic young were in a double, "twinned," condition. Various types of polyvitelly have been observed, the most common being that of two embryos of apparently equal size within one membrane (Fig. 1). These were in most cases of the normal dextral type. In three instances, however, there were within a single membrane one dextral shell and one sinistral shell (Fig. 2). In one case the sinistral shell was nearly three times longer than the dextral shell showing definitely a case of unequal development (Fig. 3). This instance of unequally developed embryos does not support the theory of simultaneous, accidental engulfment of more than one vitellus within a membrane (Crabb and Crabb, 1927), unless there was simply a retarded development of the smaller individual.

In all cases of simple duplication neither of the individuals showed an apparent abnormality and when freed from the membrane both were able to carry on normal locomotion. The only noticeable difference shown in these individuals was the smaller size in comparison with the normal young in the same uterus. This might be due to the limited supply of the albumen contained within a single egg.

Five eggs were noted containing two embryos in the veliger stage. These embryos were in every case undergoing normal movement, neither apparently hindering the other. Various stages of the veliger stage were exemplified showing that the duplication did not occur in this period.

Only in one case have there been found more than two embryos within a single membrane. This set contained one large normally developed dextral young which was seemingly ready for extrusion from the uterus. The other two contained in the membrane with it were both very much dwarfed and possessed abnormal shells. These shells were not fully coiled and were very irregularly twisted and contorted. One of these small embryos was, when found, wedged in the aperture of the larger individual with the second abnormal one held firmly in contact with the first by the tightly drawn egg membrane. During the examination of this set of "triplets" the membrane burst making it impossible to sketch the group intact.

The presence within the same membrane of individuals showing a conspicuous difference in size and lack of uniformity in the type of abnormalities argues against the probability of these young having resulted from isolation of the blastomeres of the same egg or fragmentation of the early embryo. The writer is therefore of the opinion that the individuals within the same membrane are not true twins but represent instances of polyvitelly, a view advanced in other molluscan studies mentioned above.

Double Monsters.—The occurrence of double monsters in fresh-water snails, although not frequently recorded, has been referred to by several authors. Experimental and non-experimental explanations have been offered, the experimental methods generally proving unsatisfactory.

DeLacaze-Duthiers (1875) in a study of double monsters in *Philine aperta* found that during early stages of polyvitelline eggs the two embryos came in contact with each other while in the act of cleavage and fused at the point of contact. Pelseneer (1920) presented, in what is probably one of the most comprehensive works of its kind, his study of the development of double monsters in several species. Pelseneer produced artificially in *Physa fontinalis* double monsters while the embryos were in the gastrula stage, but not after the embryos had reached the veliger stage. This author concluded that double or conjoined embryos are the result of more than one egg being contained within a membrane. Stockard (1921) stated his belief that in the mollusca double monsters are the result of budding. MacCurdy (1909) found among the free young of *Campeloma* a double snail possessing two normal shells with a fusion of the two bodies. Crabb in his work with *L. stagnalis appressa, L. palustris* and *P. gyrina* found that all double or conjoined embryos were the result of fusion of more than one egg within the same membrane. Winsor and Winsor (1932) expressed a belief that some hereditary factors influence the production of double or triple monsters in *L. columella.*

The present study of *Campeloma rufum* has been strictly observational. Individuals with various degrees of conjoining of the soft parts have been observed and it seemed worth while to describe these abnormalities since these observations so closely harmonize with experimental conclusions of other workers.

The type of union found most frequently was that of the conjoining of the two embryos by the oral surface or anterior end of the two visceral masses as represented in Figure 4. Six double embryos of this type have been found (Table 1). The pair represented in Figure 4 exemplifies this form with the two complete but not always perfect shells. Upon clearing with benzol, the digestive tract of each individual could be seen clearly extending normally to the rostrum. The fusion, in most of these forms, was directly oral with varying degrees of twisting from one side to the other. The feet were also turned to one side, the anteror edge of one being fused to that of the other. In no one such double monster was the rostrum of one found fused to that of the other. It is doubtful if any of these forms would develop to the point of birth as many of them found in the uterus were dead.

A similar type of oral fusion has been found in the veliger stage (Fig. 5).

Individuals of various sizes and types of fusion have been observed in this stage. This upholds the theory of Pelseneer that such fusion takes place before the veliger is formed.

Two individuals which were bicephalic have been found (Table 1). Figure 6 represents one of these embryos after the body was removed from the shell. Each of these two monsters bore a normal dextral shell, the abnormality being detected only when the anterior end of the body was extruded from the aperture. These individuals were removed from the shell, dehydrated in alcohol, cleared in oil of wintergreen and mounted in balsam. A study of the anatomy was thus made possible. The posterior half of the body was normal, the division into two anterior parts arising about midway of the body. The digestive tube was divided into two distinct anterior parts, each ending in a normal mouth and each containing a radula. There were two normally developed head regions each with a rostrum, two eyes and two tentacles. The body was divided externally to form these two head regions anterior to the point of division of the digestive tract. There was only one mantle extending across the body posterior to the point of division. The foot was extended laterally in an abnormal condition with the anterior part cleft, giving each head the appearance of having a separate foot region. One of these individuals lived in an aquarium for two days after a premature removal from the uterus. Locomotion was normal with very little or no tendency toward uncoördinated movement.

One double snail was found similar to the one described by MacCurdy (1909). This monster possessed two separate dextral shells slightly smaller than the normal type and two distinctly separate bodies, except at the point of fusion. The right, posterior edge of one individual foot was fused to the left, posterior edge of the other foot (Fig. 7). There was no apparent connection between the two individuals other than this joining of the foot tissues. The conjoining was such that locomotion would probably be impeded by the direct opposition of the movements of the one to the other. This embryo was dead when removed from the uterus, after the adult had been killed by immersion in hot water, thus making a study of the live form impossible.

One individual young was found which was normal in every respect except that it had three tentacles, three eyes and an extra rostrum (Fig. 8). This monster had a dorsal rostrum of normal size on each side of which was a normal tentacle and an eye. On the right lateral side of the anterior end of the body was a small undeveloped rostrum and one extra tentacle and eye. The parts gave the appearance of having budded off the body just anterior to the mantle line. Such a form tends to uphold the budding theory of Stockard (1921). These extra structures did not hinder the forward movement of the embryo after a premature removal from the uterus.

Another individual which exemplifies Stockard's theory showed an abnormal development of the rostrum. This young was normal in all features except for a dorsal, horn-like projection on the rostrum. The projection extended from the median dorsal side of the body from under the edge of the mantle. It possessed the form of an extra rostrum and of nearly the same

size except for its up-curved position dorsal to the normal rostrum. This individual was normal in its activities and could retract this extra process with the rest of the head region.

These abnormal forms occurred in such numbers and variations as to make them worthy of note. They show definitely that abnormal forms do occur frequently in *Campeloma rufum*. As to their formation the present work is not conclusive. Evidences here assembled tend to indicate that abnormal young may be produced by more than a single set of conditions.

Abnormal Shells.—Many uterine embryos possessing abnormal shells (Table 1) have been encountered in this study of *Campeloma rufum*. These abnormalities consist of elongated shells, shells with incomplete coiling and those showing different degrees of flattening. In most cases the embryo was either dead when found or very degenerate in its development. In the present study the high incidence of deformity in uterine shells and almost complete absence in the free living forms leads to the conclusion that at least in *Campeloma rufum* the simple mechanical explanation of Stubbs (1898) and other writers on this subject is untenable.

One uterine young (Fig. 9) possessed a very elongated and asymmerically coiled shell. Instead of the normal closely coiled and more or less compactly compressed type this shell was abnormally spiralled and twisted. The apical whorls were not joined as in the normal individuals, but loosely extended in a tube-like form with little or no connection between the coils. The body whorl was ovately elongated, inflated and encircled by irregular striae. The body of this snail was extended in an abnormal manner developing outside of the shell instead of within the coil. The body, which was alive when found, was bent and twisted forward and laterally.

Various degrees of the flattening of the embryonic shells was found. One individual removed prematurely from the uterus possessed an abnormal flattening of the spire to such a degree that in lateral view it seemed to lack entirely the apical whorls (Fig. 10). The spiral arrangement of the apex was absent, all of the coils arising on the same plane with only the body whorl becoming extended. The body whorl and the live embryo appeared to be normal in every respect.

Numerous individuals were found that were abnormally flattened to give a discoidal appearance. Figures 11 and 12 illustrate such forms. These lacked entirely the normal closely coiled condition. The umbilicus was open and the shell was completely devoid of elevation of the spire. In most of these forms, as Figure 11, the coil was regular with the last whorl loosely coiled over the terminal whorl. In one individual, however, the second whorl developed under and around the terminal coil in such a way that the distal end of the shell was contained within the aperture (Fig. 12). This enclosing of the aperture by the terminal end of the shell was marked by a stricture in the shell probably caused by an uneven rate of development or injury to the developing shell or mantle. The embryo was dead when found.

Other dead individuals were found, as in Figure 13, that had lost all semblance to the coiled condition. In every case such a shell was very much

compressed and did not contain a live embryo. All were marked with irregular striae and in some cases were slightly carinated.

These abnormal shells of *Campeloma rufum* are all probably formed by early embryological disturbance. Many are probably due to unusual pressure in a crowded uterus or to injury to the egg. This opinion is held because of the finding of the abnormal shells within broken membranes entirely lacking the protective, as well as nutritive, albuminous contents. They are of sufficient number to make them worthy of notice and to state that abnormal shell developments do occur relatively frequently in this species.

SUMMARY

1. In the embryonic young of *Campeloma rufum* 2.7% of the total number studied were in a twinned or polyvitelline condition.

2. Two dextral young were found within the same membrane on 23 occasions; only in three instances were one dextral and one sinistral form found within the same membrane.

3. Polyvitelly in the veliger stage was found.

4. One instance of three individuals enclosed within the same membrane was noted.

5. Double monsters with various degrees of fusion of the soft parts are described and figured in this work.

6. A conjoining of the oral surfaces, bicephalic individuals and a fusion of the foot tissues were the different types of double monsters found, representing 0.67% of the total number of embryonic young examined.

7. 2.3% of the uterine young examined possessed abnormal shells.

8. Elongate and asymmetrically coiled shells, flattened, discoidal forms and shells compressed without coiling were encountered in this study.

9. A mechanical disturbance of the developing embryo has been suggested as the cause for malformation of the embryonic shells.

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TABLE 1

Showing the occurrence of abnormal forms in the uteri of *Campeloma rufum*

Height of Adult in mm.	Normal Veliger	Normal Young	Sinistral Young	Shelled Twins	Veliger Twins	Fused Double Embryos	Abnormal Shells
30.0	2	25	2				
25.2	6	2			2		
25.0	2	7			1		1
27.5	6	9	1	1			
26.4	4	4			1		
26.0	0	3	1				1
33.0	2	18		2			
27.3	7	13	1	2			
36.5	15	31	1	1		1	
26.0	3	19	2	2			1
27.0	0	12		1			2
26.0	6	12	1				
25.0	6	11			1		1
25.2	7	15					1
28.8	11	23		1		1*	
25.2		7		2			2
26.2	0	11		1			
29.5	0	29	6	7			1
30.0	3	48				1*	1
29.0	12	14	1				
30.0	7	26		1			1
28.1	5	11			1		1
29.3	12	8	2				1
27.0	0	4					1
26.7	3	12					4
26.0	0	0	3				
26.1	4	14	1				2
25.5	6	9	1	1			2
30.0	2	25	2				
26.9	0	19	2				
26.2	6	6			1		
25.0	6	11	3	1			
unrecorded adults	?	?	9	3		5	4

(Note) * bicephalic embryo.

These results are from 274 adults examined for uterine contents. 1191 uterine young were examined of which (from above table) 39 or 3.2% were sinistral; 32 (shelled and veliger) or 2.7% were in a twinned condition; 8 or 0.67% were fused double embryos and 27 or 2.3% possessed abnormal shells.

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PLATE 5

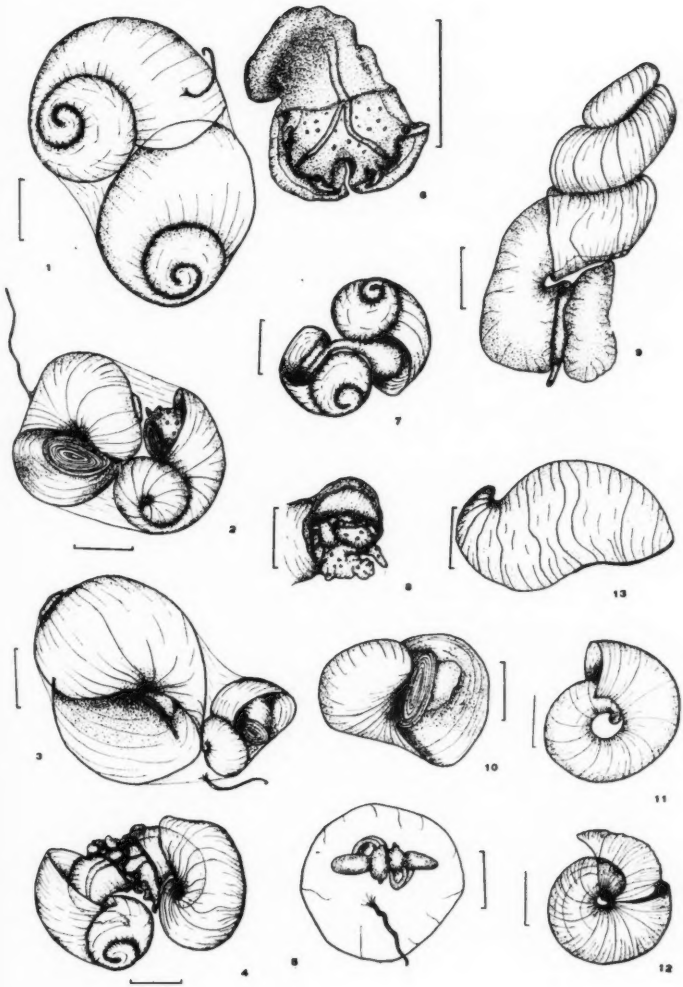
(Abnormalities in the uterine young of *Campeloma rufum)*

FIGURES

1. Two normal, dextral embryos within a single membrane.
2. One dextral and one sinistral embryo within a single egg membrane.
3. Large sinistral embryo and a much reduced dextral embryo within a single membrane.
4. Double embryo with fusion of the rostrum of one to the other.
5. Double embryo of the veliger stage.
6. Bicephalic monster possessing two heads, four eyes and four tentacles, digestive tract shown divided.
7. Double embryo with a fusion of the foot of one to the foot of the other individual.
8. Embryo monster with three eyes and three tentacles seen from an oral view of the head only.
9. Lateral view of an abnormally elongated shell.
10. Frontal view of an embryonic shell which lacked entirely the normal spire.
11. Apical view of a discoidal embryonic abnormality.
12. Apical view of a discoidal abnormality with the aperature engulfing the terminal end of the shell.
13. An abnormally flattened embryonic shell, view from upper side.

All drawings made from camera lucida outlines. The scale indicated equals 1 mm. in all cases.

PLATE 5



BIRDS OF THE WINSLOW, ARKANSAS, REGION

J. D. BLACK

Introduction

In the original conception of this paper it was intended merely to give a list of my own observations of bird life within the Winslow area. Since the actual beginning of the work it has become quite evident that the value of this study would be considerably enhanced if a direct comparison was made with the study of Austin Paul Smith over the same area several years earlier. Smith's paper (1915) has therefore been freely drawn upon in the preparation of the present work, and comparisons have been made throughout between his findings and those of the present writer. Both papers are limited to an area within a ten mile radius of Winslow. Notwithstanding this remarkable differences are to be found in the distribution of species, as well as in the actual species present. These variations are to be explained by a number of significant facts.

The survey made by Smith in 1913 and 1914 was the result of rather intense collecting over an exceptionally favorable territory so that what was lost to his study through the limited time allowed for it was made up for in a great measure by the thoroughness of the work over the period in question. Having lived most of my life within the Winslow area I have carried on eleven years of continuous work there and have within the three years since that time made four field trips back into the area. I have enjoyed many advantages which come from long study in a given locality.

Consideration, too, must be given to the ever changing status of bird life, a factor which will be introduced at greater length within the body of this paper. It has been a very important element in an effort to account for the different findings of the two studies. Important as these two elements are, however, the decided variations in the final results of the two studies cannot be completely explained by them. A very fundamental difference is to be found in the actual area studied. Although the limits of range of study as given in each paper are the same, the region is so varied in topography that it is quite possible for two students to work the same territory and yet specialize in far different faunal areas. Although the combined work of Smith and myself probably gives the Winslow section the most complete record of any like territory within the state, the task is far from complete.

The work of Smith, according to information he has kindly furnished in various letters, was intensified on the high plateau somewhat south of Winslow, and in the ravines immediately adjacent to that region. He gives the elevations of his work as from 1800 to 2200 feet; this would practically confine his study to the plateau and the nearby ravines. On the other

hand the additions and notes given herewith have been compiled for the most part from the territory immediately north of and adjacent to the village of Winslow, at elevations ranging from 1400 to 2000 feet. The differences in bird life between these two areas is not so evident in ordinary field experience, but becomes so when a comparison of the distribution of certain forms is made on the basis of the two studies.

The village of Winslow is situated at the head of a rather large valley, with arms of the Boston Mountain plateau extending down on the east and west sides, the south end of the valley being closed by the main body of the highland, sometimes known as the "Ozark divide." Water draining into the Winslow valley and to the east flows north into the White River, while most of that falling to the south and west of the village flows southward through Clear Creek, Lee's Creek and Blackburn Creek into the Arkansas River. The valleys in the south half of the region are somewhat more sharp in descent and decidedly more rugged in character than those to the north. The village has an officially recorded elevation of 1734 feet at the Frisco railroad station. The surrounding hills range from 1850 to 2000 feet in height, attaining an elevation of perhaps 2250 feet at Signal Mountain and one or two other points.[1] The mean annual temperature at Winslow is 56.2 degrees F. The total average annual rainfall is 51.29 inches. Rainfall is well divided throughout the year, with a minimum monthly average of 2.30 inches in February and a maximum monthly average of 6.95 in May. Mid-summer droughts, however, are not uncommon, the fluctuation each year being considerable as to the periods of drought and rain so that the averages are not clearly indicative of the actual situation. The temperature extremes are represented by a mean average of approximately 35 degrees in January and of 76 degrees during the last two weeks of July and the first two weeks of August.[2]

The plant life of the zone is typical of the southern deciduous forest. The various oaks, *(Quercus alba, Q. velutina, Q. rubra, Q. coccinea* and others) are the dominant trees. The hickories (especially *Carya ovata, C. alba* and *C. glabra)* are also quite common. Other trees characteristic of the area include the black walnut *(Juglans nigra),* the chinquapin *(Castanea pumila),* the black gum *(Nyssa sylvatica),* and several of the maples. The most characteristic of the trees along the streams are the sycamore *(Platanus occidentalis),* and the sweet gum *(Liquidamber styraciflua).* Along the smaller streams the witch-hazel *(Hamamelis virginiana)* is especially abundant, as is the hawthorn group *(Crataegus* sp.), several species of which are represented. The most common of the undergrowth plants is the Indian currant *(Symphoricarpos orbiculatus),* although the wild blackberry *(Eubatus* sp.) is extremely common

1 The elevations given here are estimates, made as carefully as possible and considered conservative, based on work by the United States Geological Survey (U.S.G.S., 1916). In a previous paper (1932a) I gave the elevation as upward to 2500 feet. Further careful work in the area convinces me this is too liberal, although elevations of as great as 2750 feet are claimed.

2 Meterological data concerning Winslow have been supplied by the Little Rock, Arkansas, office of the United States Weather Bureau.

and very important with relation to bird life. Only one small group of pine trees is known, the specific identity of which I have never attempted to determine. This is a cluster of transplanted trees, some now quite large, on Signal Mountain. The red cedar *(Juniperus virginiana)* occurs quite rarely through the area except in tracts of underbrush that have been occupied in recent years by robins in their winter roosts. In such places the young cedars have sprouted up in countless numbers, but are not at this time large enough to be of ecological significance. About 90 percent of the area is forested or given over to underbrush, settlement in the area since Smith's study being offset by the abandonment of land in the southern portion of the region.

Smith (1915) lists 143 forms in his paper; the present work lists 175. Of those reported by Smith only one, *Ammodramus bairdi*, is here omitted. In a letter from Smith under date of August 4, 1933, he asks that this species be removed from the list as the specimen on which it was based proved to be an abnormal specimen of *Ammodramus savannarum australis*. The Arkansas record being based on this specimen alone, will, therefore, necessitate the removal of *A. bairdi* from the list of Arkansas birds. Of the remaining 142 forms on Smith's report, two, *Elanoides forficatus forficatus* and *Meleagris gallopavo silvestris*, are almost certain to be now extinct within the limits covever by this study. Two additional extinct species are added in the present paper, as they are known to have occurred within comparatively recent years. Thirty-one others which Smith did not find are also added.

It may be readily understood from the preceding paragraphs that no necessity has appeared to question any of Smith's records. It is apparent that his compilation was carefully made, with all questionable records based on specimens. In making the present list I have tried to follow the same plan. Where previous records based on specimens stood as precedent it was not felt that actual specimens were necessary. In all other cases, with the two exception of *Bombycilla garrula pallidiceps* and *Prothonotaria citrea*, both birds of unmistakable characteristics and both known to occur within the state, the records given here are based on specimens collected. Such a plan, of course, eliminates quite a large number of sight records, most of which are undoubtedly correct, but I feel that far too many records from Arkansas (as well as many other places) are poorly sustantiated. It appears better to have a small list based on actual specimens than a more extended list which cannot be substantiated by museum material.

The three published works on the birds of Arkansas (Howell, 1911; Wheeler, 1924; Baerg, 1931) have been consulted frequently during the present study, but inasmuch as Howell did not visit the Winslow area and the records of the latter two authors appear to be based almost solely upon Smith's paper they have not had any direct bearing on the present work. The specimens on which additions to the Winslow fauna given here are based are for the most part now either in the collection of Dr. Louis B. Bishop, of Pasadena, California, or the Museum of Birds and Mammals, University of Kansas. A few are in the collection of J. A. Munro, of Okanagan Landing, British Columbia. All specimens of doubtful identity have, except where

otherwise noted, been identified either by the Bureau of Biological Survey or by members of the staff of the United States National Museum. Dr. Louis B. Bishop has rendered many favors which has made possible a more complete and accurate listing of the Winslow avifauna, as has Austin Paul Smith, both placing all their valuable data at my disposal. The list which follows has been arranged to conform with the fourth edition of the Check-List of North American Birds, of the American Ornithologists Union, and the names used herein are the same as employed in that publication.

Annotated List

Podilymbus podiceps podiceps (Linnaeus). Pied-billed Grebe. Three records, all specimens having been collected by myself. Dates are April 28, 1926; April 10, 1929; and April 29, 1931. Although not known to occur in the fall it is highly probable that it is a fall migrant in limited numbers. The nature of the area around Winslow is such that records for water birds of this type are difficult to secure. Fall specimens have been taken at Fayetteville.

Pelecanus erythrorhynchos Gmelin. White Pelican. Known as a rare migrant. One bird kept captive for several months by a farmer on Blackburn Creek, about 6 miles southwest of Winslow. The bird had suffered a broken wing, and was released when finally able to fly again.

Ardea herodias herodias Linnaeus. Great Blue Heron. Not uncommon on the larger streams in the late summer. One specimen in my collection was killed July 16, 1931, six miles east of Winslow.

Casmerodius albus egretta (Gmelin). American Egret. The bird appears to be not uncommon along Clear Creek (the Frog Creek of Smith's list) in Crawford County, as well as along the streams north and west of Winslow. I have observed it several times in late July on Clear Creek. Two specimens in my collection, both taken five miles north of Winslow, are dated July 8, and August 6.

Florida caerulea caerulea (Linnaeus). Little Blue Heron. A common summer visitor on the streams around Winslow, appearing early in August and remaining until about the middle of September. There is one spring record, April 21, 1929.

Butorides virescens virescens (Linnaeus). Eastern Green Heron. A rather common summer visitor. There are no nesting records, although the bird is frequently observed throughout the summer.

Cygnus columbianus (Ord). Whistling Swan. "A solitary bird killed during the winter of 1912-13 on Frog Creek, near Porter, Crawford County, was probably of this species." (Smith, 1915). Nothing can be added to this report. Porter is about nine miles south of Winslow.

Branta canadensis canadensis (Linnaeus). Common Canada Goose. A common migrant. Hunters secure one or two birds each fall, but as a rule it does not stop within this area. The earliest spring record is Feb. 8, 1928, when over 600 were seen.

Anas platyrhynchos platyrhynchos Linnaeus. Common Mallard. A com-

mon migrant, often stopping on the small streams near here, and on Nelson Pond, west of Winslow.

Querquedula discors (Linnaeus). Blue-winged Teal. Fairly common migrant. My earliest record is April 1, 1928, April 11 and 12 being the usual early dates. I have one mounted specimen shot on Nelson Pond in the latter part of August, 1925, the exact date being unknown.

Nyroca affinis (Eyton). Lesser Scaup Duck. Only two records. One bird was found dead April 13, 1929 and another found wounded April 21 of the same year, the latter specimen dying May 5th.

Cathartes aura septrionalis Wied. Turkey Vulture. "Present most of the year, retiring about December 1 to below 1500 feet; but reascending toward the end of February. A few could be noted almost daily but to find any number in company was unusual." (Smith, 1915). This has continued to be the condition until this past summer when the extreme shortage of all wild life was reflected in the almost total absence of vultures from the area.

Coragyps atratus atratus (Meyer). Black Vulture. Although not nearly so common as the preceding it is always to be found from April until November. My earliest record is April 10. I am of the opinion that it is more common in the Clear Creek region than elsewhere; it is rarely observed above 1700 feet.

Elanoides forficatus forficatus (Linnaeus). Swallow-tailed Kite. Smith (1915) reports a sight record by a farmer near Winslow, Oct. 8, 1913. I have heard of no later record. Once apparently common here as a transient.

Astur atricapillus atricapillus (Wilson). Eastern Goshawk. A single specimen was shot at Winslow, Nov. 5, 1926. It was a large adult female. Baerg (1931) reports that a single specimen was killed "not far from Fayetteville during the winter of 1928-29." There appears to be no other record for the state, excepting the Fayetteville specimen.

Accipiter velox velox (Wilson). Sharp-shinned Hawk. Fairly common as a migrant, especially in the fall. Smith recorded one specimen here on July 24, 1913. My earliest fall record is October 28.

Accipiter cooperi (Bonaparte). Cooper's Hawk. A fairly common resident. The bird is a serious enemy to the chickens on the small mountain farms of the region. Its raids, together with those of the grey fox, often makes it almost impossible to raise poultry in certain localities. This species is especially common during the summer.

Buteo borealis borealis (Gmelin). Eastern Red-tailed Hawk. A very common resident. I have found this hawk quite common throughout the year. Smith (1915) reports it as occurring principally as a fall and winter visitor. Baerg (1931) lists it as a resident for the state, but considers that it nests in small numbers only. This is not now the case in the Winslow region where it is by far the most common of the hawks of all times of the year. Three specimens were shot in the act of killing grown hens. Although generally beneficial in this region, as elsewhere, it appears to be more of an enemy to

poultry here than commonly is the case. It is known as the "hen hawk" to most of the farmers and is hunted even more than *Accipiter cooperi*.

Buteo lineatus lineatus (Gmelin) .Northern Red-shouldered Hawk. Smith (1915) reports this as the most abundant hawk within the area and a summer resident. I have never seen the bird near Winslow. If now present at all it is extremely rare. Apparently it has been replaced since the time of Smith's studies by *borealis*.

Buteo platypterus platypterus (Vieillot). Broad-winged Hawk. Reported by Smith (1915) as a transient and possible summer resident. Other than two immature females, shot July 23, 1927, I have found it as a fall migrant only. It is probable that these two July specimens were raised within the area as they were shot from a group of five, of which only one was an adult, and appeared to have not been out of the nest a great while. It is not especially rare in the fall, though not to be considered common.

Buteo swainsoni Bonaparte. Swainson's Hawk. Smith (1915) observed a single bird October 1, 1914. I have never seen the species.

Aquila chrysaetos canadensis (Linnaeus). Golden Eagle. The only authentic record for the region is that of a specimen collected by Smith (1915) October 18, 1913.

Haliaeetus leucocephalus leucocephalus (Linnaeus). Southern Bald Eagle. An accidental visitor. Smith (1915) reports the observation of single individuals on May 6 and September 29, 1914. I have reported elsewhere (Black 1929a) the only other positive record for the locality. It doubtless occurs rather frequently, because reports of its presence are heard on the average of two or three times a year.

Circus hudsonius (Linnaeus). Marsh Hawk. Not a rare migrant, but never really common. Apparently does not winter here. Most often seen in October and November. I have observed it as early as August 26 (1933) at Fayetteville, but have not found it in the Winslow region before the last part of September.

Falco columbarius columbarius Linnaeus. Eastern Pigeon Hawk. Very rare migrant. Smith (1915) gives one definite record for this species, on Sept. 22, 1913. I secured an immature female shot in the village of Winslow, Sept. 12, 1934. It is known only from these two specimens.

Falso sparverius sparverius Linnaeus. Eastern Sparrow Hawk. Rare. I have collected this species only twice, both times in November. Smith (1915) reported specimens in May and June of 1913, and January and August of 1914. It is probably a resident, but very rare as such.

Colinus virginianus virginianus (Linnaeus). Eastern Bob-white. Common resident. Not nearly as common, however, as the cover and food supply could support. The bird should occur in double its present numbers under ordinary conditions, but it is so heavily preyed upon by the bob cat and grey fox that it has lost ground instead of having gained within the last five years. The great horned owl is also a probable important factor in controlling the numbers of the bob-white.

Meleagris gallopavo silvestris Vieillot. Eastern Turkey. Smith (1915) listed one actual record; that of a flock of seven seen by a hunter near Clear Creek in Crawford County in early December, 1913. It is quite certain extinct within this section now and has been for at least ten years. The available cover offers an excellent opportunity for the stocking of areas near Winslow now planned, but the species will have very little chance to survive the predators now so common within the region.

Porzana carolina (Linnaeus). Sora. A rather rare migrant. One specimen, captured May 20, 1929 and banded with U. S. Biological Survey band No. 670771 and released. Skins in my collection from this locality were taken on the following dates: May 1, 1930; May 12, 1931; October 9, 1929. Two of the four birds were found dead on the highway, evidently killed by cars.

Fulica americana americana Gmelin. American Coot. Not especially rare as a migrant, but rather irregular in its appearance. There are records of April 13, 1930 and October 26 and 28, 1928. All were picked up far from water in exhausted conditions. They are occasionally reported from Clear Creek in both the fall and spring.

Oxyechus vociferus vociferus (Linnaeus). Killdeer. A common migrant in the vicinity of Nelson Pond. Elsewhere I have noted it only rarely. My earliest date for spring arrival is March 31, 1929.

Actitis macularia (Linnaeus). Spotted Sandpiper. A fairly common migrant and a rare summer resident. I have observed one family of young, just out of the nest, one mile north of Winslow, and another at Schaberg, five miles south of Winslow. A few other birds have been seen during the breeding season.

Tringa solitaria solitaria Wilson. Eastern Solitary Sandpiper. A rare migrant. The only specimen in my collection was taken at Nelson Pond May 18, 1929.

Totanus flavipes (Gmelin). Lesser Yellow-legs. Observed in small numbers almost every spring at Nelson Pond. One specimen was collected from a flock of four there April 28, 1929. Inasmuch as this appears to be the first published record for the bird from the western portion of the state, it might be well to add that one specimen was collected May 7 of the same year at Fort Smith, three others observed there the following day, and it was reported as common around Fort Smith during the spring migration. There is also one fall record from Nelson Pond, September 4.

Pisobia melanotos (Vieillot). Pectoral Sandpiper. Only one record, that of May 12, 1931 when five birds were seen and one collected at Nelson Pond. This record has been previously published (Black, 1931). It appears to be the only known record for the western part of the state.

Steganopus tricolor Vieillot. Wilson's Phalarope. One record only of four birds seen and one collected at Nelson Pond, April 28, 1929. The specimen collected was a female. mounted and in my collection. This appears to be the first published record for the state for the species. A single female was ob-

served at Fort Smith, May 7, 1929, in company with the yellow-legs mentioned above.

Zenaidura macroura marginella (Woodhouse). Western Mourning Dove. Although this bird is considered a winter resident within the northwest section of the state and I have observed it throughout most of that section during the winter months, it is apparently a summer resident only within the limits of the Winslow area. Smith reports it as arriving about April 1. (Smith, 1915). This is quite true of the elevations at which he did most of his work, but I have observed it as early as February 18 (1928) at 1700 feet. It commonly arrives around Winslow in March, usually the first week of that month. The bird becomes rare, even at 1500 feet, after the last of October. Both Albert Lano of Fayetteville and Smith have referred specimens from this section to the western sub-species, identifications which were substantiated by the Biological Survey. It is highly probable that both *marginella* and *carolinensis* occur within this vicinity during migration, but *marginella* seems to be the breeding form.

Ectopistes migratorius (Linnaeus). Passenger Pigeon. Once quite common throughout this section. No definite date as to the last record is to be obtained.

Coccyzus americanus americanus (Linnaeus). Yellow-billed Cuckoo. A very common summer resident, arriving as early as May 2, and remaining at least until October 12. In the fall of 1928 several nests of this bird were found very late in the season. Photographs were made of young in the nest of about five different nests on September 11, 12 and 16th, all of the young still being in quills.

Coccyzus erythropthalmus (Wilson). Black-billed Cuckoo. Smith (1915) reported two specimens taken May 22, and one on September 17, of 1914. He considered it a migrant only. I have never made a positive record of the occurrence of the species during my study in the region. It is presumably a very rare and shy migrant.

Otus asio asio (Linnaeus). Southern Screech Owl. Fairly common resident. All specimens observed or collected, except three, have been of the red phase. Probably as common as *Strix varia varia*.

Otus asio aikeni (Brewster). Aiken's Screech Owl. Dr. Louis B. Bishop has referred two winter specimens from Winslow to this race, the birds being taken on January 15, 1929 and January 19, 1930. In view of the pronounced west-east migration which is known to have occurred within recent years this is not as remarkable as it might appear at first thought.

Bubo virginianus virginianus (Gmelin). Great Horned Owl. A common resident. Apparently able to maintain its status in the deeper ravines throughout the area, where it is quite common, in spite of almost continual trapping and hunting. It often raids chickens roosting in trees, and the habit of many of the farmers of this section to fail to provide proper housing for their poultry raises this species into the front rank as an enemy of poultry within the mountain portion of Arkansas.

Strix varia varia Barton. Northern Barred Owl. Fairly common resident. In sharp distinction to the changed distribution of the hawks in recent years and at the time of Smith's studies, the relative abundance of the owls seems to be about as he found it.

Strix varia alleni Ridgway. Florida Barred Owl. A single specimen, evidently a wanderer, of this race was taken here January 25, 1931. There is no other record for this section.

Antrostomus carolinensis (Gmelin). Chuck-will's-widow. A common summer resident. By far the most common of the family within this area, and is to be seen in almost any open patch of timber at nightfall throughout the summer. It is surprising that Smith did not record this species.

Antrostomus vociferus vociferus (Wilson). Whip-poor-will. Fairly common as a summer resident, and no doubt a breeding bird, though there are no nesting records.

Chordeiles minor minor (Forster). Eastern Nighthawk. A rather rare spring migrant but appears in great numbers in the fall. Frequently in the fall, and especially in late afternoon just after a rain, the birds appear in numbers of from 200 to 1000 over the larger valleys. Several specimens from such flocks have been collected, and in every instance their stomachs have been filled with winged ants of various species.

Chordeiles minor chapmani Coues. Florida Nighthawk. Specimens taken in this region in the fall and during the breeding season appear to vary from almost typical *chapmani* to stages intermediate between this race and *minor*. On the whole it appears best to refer all breeding specimens to the race *chapmani* because the tendency is greater toward that race than *minor*. It is probable that the breeding form for the entire state is *chapmani* or an intermediate phase.

Chaetura pelagica (Linnaeus). Chimney Swift. Common summer resident, arriving about April the 15th, and remaining until the first week in October.

Archilochus colubris (Linnaeus). Ruby-throated Hummingbird. A common summer resident. Always to be found in spring as soon as the blossoms of the Ohio buckeye *(Aesculus glabra)* are open. Apparently the bird feeds for the first two weeks of its stay almost exclusively on this plant.

Megaceryle alcyon alcyon (Linnaeus). Eastern Belted Kingfisher. Common summer resident. In spite of the fact that this bird is supposed to be resident throughout this area, I have never recorded it in the winter. In the summer it is to be found along all the reasonably large streams within the region.

Colaptes auratus luteus Bangs. Northern Flicker. A very common resident, especially common except during the more severe part of the winter when it tends to move down to lower elevations. Although now common, Smith (1915) did not find this species to be a summer resident.

Ceophloeus pileatus pileatus (Linnaeus). Southern Pileated Woodpecker. A fairly common resident. Prior to 1925 this bird was common, but begin-

ning then and continuing until 1930 the species became increasingly rare until it was virtually extinct by the latter date. Since 1930 it has again been on the increase, due no doubt to the decided increase in standing dead timber within the last four years, and is again reasonably common throughout the Winslow region. The bird is very shy, and is far more often heard rattling away at an old dead tree off across the valley than it is seen. For a bird of its size and prominence it is extremely difficult to collect.

Centurus carolinus (Linnaeus). Red-bellied Woodpecker. A very common resident. I found this woodpecker rare from 1920 until 1926 and not common until about 1928. Since then it has been about as common as the flicker, and may be recorded daily throughout the year.

Melanerpes erythrocephalus (Linnaeus). Red-headed Woodpecker. Fairly common as a summer resident. Another member of the family whose changing status is an unanswered puzzle. Smith (1915) found it a common migrant, but not a summer resident in 1913 and 1914. By 1920 it was nesting in scattered localities, but not commonly. After 1924 I did not see a summer bird until 1929, when a pair was found nesting near Winslow at an elevation of 1850 feet. In 1930 three nesting pairs were known, one on Signal Mountain. It was still increasing in 1931 and 1932 and considered fairly common since then. It appears to be equally distributed at all elevations within the area.

Sphyrapicus varius varius (Linnaeus). Yellow-bellied Sapsucker. Fairly common as a migrant and hardly to be considered rare as a winter resident. Smith (1915) reported that the immature birds outnumbered the adults about ten to one, a condition which appears to still prevail. Although my extreme dates are from October 28 to April 6, the bird commonly arrives about the middle of November and departs in the third week of March.

Dryobates villosus villosus (Linnaeus). Eastern Hairly Woodpecker. Rare resident. Smith (1915) reports this bird as "About as common as the downy, possibly more frequently seen during cold weather than at other times." This is exactly the condition that existed during the first five years of my study within the area. During the winter of 1925-26 the birds were noticeably less common than before, and from that time on entries of its occurrence are increasingly rare in my field notes. Only ten were observed and three collected during the entire summer of 1932. None were seen in either of the trips back into the region in 1933, and none during eight weeks there during the summer of 1934. It has become by far the rarest of the family represented within the area, although ten years ago it was one of the two most common. Specimens from this area are very close to *Dryobates v. auduboni* and certain individuals appear to be almost typical of that form, but taken as a whole, it seems best to refer all hairy woodpeckers from this region to *villosus*. It is possible that a very extensive series of breeding birds taken on both sides of the main divide would establish the northern limits of the northern race within the Winslow area. The material on hand indicates such a condition.

Dryobates pubescens medianus (Swainson). Northern Downy Woodpecker. The most common of its family and the only member that has main-

tained its present status unchanged throughout the course of my study. The same condition as to subspecies exists with this as with the preceding species, with many specimens nearly typical of *pubescens*.

Tyrannus tyrannus (Linnaeus). Eastern Kingbird. A very common migrant and fairly common summer resident, arriving as early as May 8 and departing on or before October 21. Considerably more common at the lower elevations and very rare as a summer resident above 2000 feet.

Myiarchus crinitus boreus Bangs. Northern Crested Flycatcher. Fairly common as a migrant, especially in spring, but extremely rare as a summer resident. I have found only three breeding pairs during all my field work. Smith (1915) reported three or four breeding pairs during his studies within the area.

Sayornis phoebe (Latham). Eastern Phoebe. A very common summer resident. I have found one pair working on a half completed nest as early as March 17, and Smith (1915) reports a fall record as late as Nov. 12.

Empidonax flaviventris (Baird and Baird). Yellow-bellied Flycatcher. Smith (1915) found this bird to be a regular migrant. I have only two sight records to add, that of a single bird on May 15, 1927 and of two birds on October 13, 1929.

Empidonax virescens (Vieillot). Acadian Flycatcher. Smith (1915) says: "The common flycatcher during the period it was present, from April 28 to September 1." I have found it very common in the deeper ravines, absent elsewhere, and within the area as a whole outnumbered by the phoebe, wood pewee and the kingbird.

Empidonax trailli brewsteri Oberholser. Little Flycatcher. Smith (1915) reports two records. I have never observed it in Arkansas.

Empidonax minimus (Baird and Baird). Least Flycatcher. A rather rare but regular migrant. Smith (1915) found it to be a rather common migrant and gave dates of May 5-11 for the spring flight and September 8-16 for the fall migration.

Myiochanes virens (Linnaeus). Eastern Wood Pewee. A very common summer resident, arriving as early as April 28. It nests quite commonly along the wooded hillsides and is one of the most characteristic birds of the region.

Nuttallornis mesoleucus (Lichtenstein). Olive-sided Flycatcher. I have never recorded this species within the area under consideration. Smith (1915) reports it as uncommon but regular as a migrant, giving spring and fall dates for the 1914 migrations as May 16 and September 18.

Otocoris alpestris praticola Henshaw. Prairie Horned Lark. A fairly common resident, sometimes occurring in considerable numbers in the winter. First found nesting in 1928. I now consider the species rather common as a breeding bird. Inasmuch as it is more common at the elevations that Smith worked than elsewhere, and he did not find the bird, it is to be presumed that it did not occur there at that time.

Iridoprocne bicolor (Vieillot). Tree Swallow. This species was found by

Smith (1915) on October 2, 1913 and April 20, 1914. I have never seen it.

Petrochelidon albifrons albifrons (Rafinesque). Northern Cliff Swallow. Reported one time by Smith (1915) near the end of April 1913. Although I have never seen the bird within this area I have observed it during migration at both Fayetteville and Alma, so that it doubtless still occurs as a rare migrant.

Progne subis subis (Linnaeus). Purple Martin. A very common summer resident arriving March 13 and departing as late as September 28, though usually leaving much earlier.

Cyanocitta cristata cristata (Linnaeus). Northern Blue Jay. An extremely common resident. The seasonal difference noted by Smith (1915), with the bird less common from November to March, has not been evident in recent years.

Corvus corax sinuatus Wagler. American Raven. Although there are no specimens to substantiate a record, this species once occurred in the Winslow region in considerable numbers. "Raven Bluff," four miles southwest of Winslow, is supposed to have been so named because the region was frequented by these birds.

Corvus brachyrhynchos brachyrhynchos Brehm. Eastern Crow. Not especially common except in the early winter when it gathers into flocks of 20-50. Always to be found in small numbers, but never a serious pest.

Penthestes carolinensis carolinensis (Audubon). Carolina Chickadee. A very common resident, extremely common in winter.

Baeolophus bicolor (Linnaeus). Tufted Titmouse. A very common resident, and like the preceding, appears to be more common in winter and fall than during the breeding season.

Sitta carolinensis carolinensis Latham. White-breasted Nuthatch. Fairly common as a resident, more common in the fall and winter.

Certhia familiaris americana Bonaparte. Brown Creeper. A rare winter resident, always occurring in small numbers, but never common. Arrives as early as October 2, departing not later than April 7, usually before the end of March.

Troglodytes aedon parkmani Audubon. Western House Wren. In some years a very common spring migrant, and a rare summer resident. Smith (1915) recorded it as an uncommon fall migrant. It was exceedingly common in the spring of 1929, being present in numbers from April 20 to May 5. Formerly considered as not breeding there I found three nesting pairs in the summer of 1933, and was told that at least one pair had nested at the old site the previous year. The nests varied in elevation from the very top to the bottom of the range, so that their previous absence is difficult to understand.

Nannus hiemalis hiemalis (Vieillot). Eastern Winter Wren. A rare but regular winter resident. Always in brush piles or drift along the small streams.

Thryomanes bewicki bewicki (Audubon). Bewick's Wren. To be found as a summer resident in the higher portions of the region, but not observed regularly. I have photographed nests at Nelson Pond and Signal Mountain.

Thyrothorus ludovicianus ludovicianus (Latham). Carolina Wren. Very common resident. Known locally as the "House Wren," "Jenny Wren," and "Brown Wren," this bird is everywhere common the year round. It nests impartially under tree roots along the smaller mountain streams or around houses and barns. Three broods per summer are commonly reared, and always two. One pair (?) of these birds have been observed to use the same nesting site for seven consecutive summers for their first brood. Apparently during all this time a complete nest was never built, but the old one repaired as necessity demanded. Often the second brood is raised in the same nest as the first (Four times in seven years in the case of the above mentioned pair.).

Mimus polyglottos polyglottos (Linnaeus). Eastern Mockingbird. A very common summer resident at the lower elevations, rare but present throughout the higher elevations. A few remain throughout the winter in the warmer and more protected parts of the area. Occasionally an individual will frequent a feed table in the village all winter, even through severe weather.

Dumetella carolinensis (Linnaeus). Catbird. Perhaps the most common summer bird in the region. Much more common at the lower elevations, especially below 1800 feet. Quite as much at home in small openings along the wooded streams where the hawthorn and blackberry provide shelter, as in the farm yards and villages. Arriving as early as April 11, but usually around the 15th, the catbirds remain until the middle of October. In dry summers they retire to the larger streams about the middle of July, in company with other birds that ordinarily remains more evenly distributed, such as the cardinal and to a lesser degree the mockingbird.

Toxostoma rufum (Linnaeus). Brown Thrasher. Usually a very rare spring migrant. Common in 1929 from April 19 until May 5. The nearest nesting record to my knowledge is at West Fork, twelve miles north of Winslow.

Turdus migratorius migratorius Linnaeus. Eastern Robin. A summer resident of irregular status. Often absent or nearly so as a breeding bird, yet very common in other years. Usually represented by a few pairs of breeding birds, especially in the higher parts of the region. A winter visitor, but only rarely remaining throughout the year. Often, but not always, absent during the month of January. During the winter they often congregate in great roosts, flying out early in the morning considerable distances to feed on the berries of the common black gum *(Nyssa sylvatica)* and other berries available at that time. I have covered their winter habits in some detail in a previous paper (Black, 1932a). Friends reported that the early winter roost of 1932 was even larger than in previous years. There appeared to be no roost of any great size during the winter of 1933-34.

Turdus migratorius achrusterus (Batchelder). Southern Robin. Many of the birds of the winter roosts have been found to be typical of this race. This would apparently establish a northward migration in the fall and is a strong point favoring the argument that the movement of the species as a whole *(migratorius* and subspecies) outside of the breeding season is principally controlled by the abundance of desirable food.

Hylocichla mustelina (Gmelin). Wood Thrush. A very common summer resident throughout the region, especially so in the deep ravines, which they favor for nesting sites. It is not uncommon to see and hear as high as 100 singing males in a single afternoon around the first of May when the spring migration is at its height, their song completely dominating the forest for a few days each spring. They arrive as early as April 15, and depart about the middle of September, Smith (1915) reporting a date as late as September 21.

Hylocichla guttata faxoni Bangs and Penard. Eastern Hermit Thrush. A very rare winter resident. I have collected specimens in October, November and December, and observed it in January. It is confined to the darker, more secluded, ravines.

Hylocichla guttata dwighti Bishop. Dwight's Hermit Thrush. Dr. Louis B. Bishop, who has recently described this race (Bishop, 1933), informs me that he considers a specimen in his collection from Winslow, collected by myself, February 1, 1929, as almost typical of this race, the plumage being typical but the bill tending toward *guttata*. As Dr. Bishop says, this appears to be the eastern known limit of the winter range for the race.

Hylocichla ustulata swainsoni (Tschudi). Olive-backed Thrush. "An abundant spring and fairly common autumn transient." (Smith, 1915). Smith found it present from April 28 to May 25, and from September 7 to 18. I have only a single sight record, of four individuals, April 28, 1929, to add to this. Apparently a very irregular migrant.

Hylocichla minima aliciae (Baird). Grey-cheeked Thrush. I have recorded it only on one date, May 7, 1927. Smith (1915) reported it as a common spring migrant, not so abundant in fall.

Sialia sialis sialis (Linnaeus). Eastern Bluebird. A very common resident, sometimes disappearing for several weeks in winter, but often remaining through the most severe weather. May begin nesting as early as the second week in March.

Polioptila caerulea caerulea (Linnaeus). Blue-gray Gnatcatcher. A very common summer resident arriving as early as April 7 and departing about the middle of September.

Regulus satrapa satrapa Lichtenstein. Eastern Golden-crowned Kinglet. Rather common migrant, but rare as a winter resident. Present here during the latter part of March and in November and December. One specimen was collected Feb. 3, 1929, during one of the most severe blizzards of the winter.

Corthylio calendula calendula (Linnaeus). Eastern Ruby-crowned Kinglet. Arrives in spring on March 31, or a few days later, present until May 5-8. Arrives in fall the last of September and remains for two months or longer, but not present during the severe part of the winter.

Bombycilla garrula pallidiceps Reichenow. Bohemian Waxwing. Reported as being present and carefully described by a friend on May 6, 1931. I observed and unquestionably identified a flock of ten of these six days later as

they fed on buds of the flowering dogwood. Previously reported (Black, 1932b) as the only record from this locality.

Bombycilla cedrorum Vieillot. Cedar Waxwing. An irregular visitant. Not known to breed here. Most common in May and October, and an irregular winter visitor, but not to be considered as a winter resident. My latest data in the spring is May 30.

Lanius ludovicianus migrans Palmer. Migrant Shrike. A rare transient, only occasionally noted in the spring, more often in October.

Sturnus vulgaris vulgaris Linnaeus. Starling. One record. A single bird was shot one mile north of Winslow by Sanford Nott and sent to me, November 15, 1932. The specimen is now No. 20336 in the University of Kansas collection. It was in company with a band of robins.

Vireo griseus griseus (Boddaert). White-eyed Vireo. A common summer resident, arriving as early as April 1, and remaining until the last part of September.

Vireo belli belli Audubon. Bell's Vireo. A summer resident, but rather rare locally. Recorded in the spring as early as April 8. It is generally confined to the small streams, and more common at the lower altitudes within the area.

Vireo flavifrons Vieillot. Yellow-throated Vireo. A fairly common summer resident, sometimes quite common in migration. Smith reported it as arriving as early as April 18 (my early date is April 28). It remains until the middle of September.

Vireo solitarius solitarius (Wilson). Blue-headed Vireo. A rather rare migrant. Smith (1915) reported its presence here as a fall migrant. I have previously reported it here in the spring (Black, 1925). In 1928 I found this species to be fairly common and observed it from May 1 to 8. In 1929 only two were recorded, both on April 21.

Vireo olivaceus Linnaeus. Red-eyed Vireo. Very common as a migrant and summer resident, arriving as early as April 7 and remaining until the last of September.

Vireo philadelphicus (Cassin). Philadelphia Vireo. The first, and to date only, published record of this bird's appearance within the state was of three individuals observed by Smith (1915) on April 30, 1914. I have observed the species a few times when identification was positive. My first record was April 24, 1927 when two were recorded, and another was studied at close range for a long period the following day. Single individuals were recorded in 1928 and 1929. I am inclined to believe that careful collecting would establish the species as an uncommon but regular spring migrant.

Vireo gilvus gilvus (Vieillot). Eastern Warbling Vireo. A fairly common summer resident and a very common spring migrant. Smith's (1915) dates of arrival and departure, April 27 and Sept. 9 correspond with mine, except for the year of 1928 when they arrived on April 1, and were repeatedly observed thereafter, becoming common by the 18th.

Mniotilta varia (Linnaeus). Black and White Warbler. A common summer resident. Present from the first of April until the middle of October. Throughout the summer the most common member of the family, sometimes being very common in the spring.

Protonotaria citrea (Boddeart). Prothonotary Warbler. A pair of these birds were observed one mile north of Winslow on May 27, 1929 by a party of three, including myself. I know it in the Winslow region only from this record.

Helmitheros vermivorus (Gmelin). Worm-eating Warbler. Smith (1915) reported three or four pairs nesting in a single ravine in 1914, arriving April 22, and departing Sept. 14. I have never observed the species.

Vermivora chrysoptera (Linnaeus). Golden-winged Warbler. "The first and only record from this region as well as for the state is of a single bird found in a grove, mostly consisting of witch-hazel, in a ravine bottom, May 16, 1914." (Smith, 1915) Apparently the state record still rests on this one observation.

Vermivora pinus (Linnaeus). Blue-winged Warbler. A fairly common spring migrant. Smith (1915) reported it as a breeding bird in small numbers. I have recorded it in the fall on September 18, and October 14. On the latter date in 1928 I observed 20 of these birds in a single maple tree in company with 25 *Vermivora r. ruficapilla*, 1 *Dendroica v. virens* and 17 *Corthylio c. calendula*. My earliest date for spring arrival is April 21.

Vermivora bachmani (Audubon). Bachman's Warbler. Smith (1915) collected one of these birds at an elevation of 2000 feet, May 5, 1914. It has not since been recorded in this region. The country here is decidedly unsuited for the species and the one collected was unquestionably a straggler.

Vermivora peregrina (Wilson). Tennessee Warbler. Fairly common in spring, arriving as early as April 8, usually about two weeks later. Not recorded in the fall.

Vermivora ruficapilla ruficapilla (Wilson). Nashville Warbler. A regular migrant, but both Smith (1915) and myself found it to be rather limited in numbers, only in the flight of Oct. 14, 1928, already mentioned, have I found more than an occasional individual. Smith's dates of "latter half of April," and "present in the month of September, after the 8th" are somewhat earlier than mine for both seasons.

Compsothlypis americana pusilla (Wilson). Northern Parula Warbler. A fairly common spring migrant and present as a summer resident, extreme dates being from April 6 to Sept. 24. Appears to prefer the sweet gum growth on the south side of the area, and rarely ever seen as a summer bird on the north side of the divide.

Dendroica aestiva aestiva (Gmelin). Eastern Yellow Warbler. Common summer resident, occurring in large numbers in the spring. Apparently does not arrive before May 10, and departs about the middle of September. It is surprising that this bird was not recorded by Smith (1915) as it now frequents the area with which he was most familiar.

Dendroica magnolia (Wilson). Magnolia Warbler. The only record for the species is of a single bird observed by Smith (1915) May 22, 1914. I have one or two sight records, none positive beyond question.

Dendroica coronata (Linnaeus). Myrtle Warbler. Fairly common as a migrant, and a rare winter visitor. Arrives in mid-October and seen there after rather irregularly until May 3. Not observed during the more severe parts of the winter.

Dendroica virens virens (Gmelin). Black-throated Green Warbler. An uncommon and irregular migrant. Present from April 7 to May 19 in the spring, totally absent some years. Smith (1915) reported it arriving as early as August 13 in the fall and "numerous for a month or more." My only record is of a single bird observed on Oct. 14, 1928.

Dendroica cerulea (Wilson). Cerulean Warbler. Fairly common as a summer resident within the southern part of the area where the large, dark ravines are to its liking. Smith (1915) with special opportunities to observe this species, found it fairly common as a spring migrant, arriving as early as April 16.

Dendroica dominica albilora Ridgway. Sycamore Warbler. Rare but present both as a summer resident and a migrant. Previously reported (Black, 1928) as a breeding bird on Clear Creek, where it is locally common. I have reported it in spring on April 6, and Smith (1915) reported several individuals on September 16, 1914.

Dendroica pensylvanica (Linnaeus). Chestnut-sided Warbler. Recorded only on May 6 and 8 of 1928 by myself, and on May 13 and 20 of 1914 by Smith (1915).

Dendroica striata (Forster). Blackpoll Warbler. An irregular spring migrant, common when occurring at all. In 1928 it was very common, and present from April 29 to May 25. I have recorded it as early as April 22.

Dendroica pinus pinus (Wilson). Northern Pine Warbler. Totally unknown prior to 1932, when Eugene Davis discovered breeding birds near Signal Mountain in a small clump of transplanted pines. Five or six specimens were taken during the summer and they seemed to remain in rather constant numbers throughout the season. All of the specimens collected were in the immature plumage. Possibly it is a regular resident in the pine grove mentioned. I have also taken the bird far from pine growth, 11 miles northeast of Winslow. Smith (1915) recorded several individuals in a migration wave on Sept. 29, 1914, his only Winslow record.

Dendroica discolor discolor (Vieillot). Northern Prairie Warbler. Smith (1915) reports the bird as "a common summer resident, departing very early." He gives dates of arrival and departure as April 28, and "July." Due perhaps to the difference in the area where we have worked, I have found it far from common.

Seiurus aurocapillus (Linnaeus). Oven Bird. One of the most common

of the warblers as a summer resident, and sometimes very numerous as a migrant. Arrives by April 7, and departs about September 15.

Seiurus noveboracensis notabilis Ridgway. Grinnell's Water Thrush. A rare migrant. I have recorded it only on April 19, 1925 and May 1, 1927. Smith (1915) had two records, Sept. 18 and 21, in 1914.

Seiurus motacilla (Vieillot). Louisiana Water Thrush. Common as a migrant and summer resident. Arrives April 6, and departs the last of August. Common along all the hill streams of any size.

Oporornis formosus (Wilson). Kentucky Warbler. A fairly common summer resident. Arrives by April 21 and remains until the middle of September. Frequents the cut-over hillsides, especially north slopes, where it is sometimes the predominating bird.

Oporornis philadelphia (Wilson). Mourning Warbler. A very rare spring migrant. I have only one record, of a badly injured bird which died soon after I acquired it on May 21, 1929. Smith (1915) considered it comparatively rare and present from "the end of April to May 21."

Geothlypis trichas trichas (Linnaeus). Maryland Yellow-throat. A fairly common summer resident. Prefers the lower elevations where it may be found from April 6 until the latter part of September.

Icteria virens virens (Linnaeus). Yellow-breasted Chat. A fairly common summer resident. Arrives about April 30 and remains until the end of August. Throughout the area, but more common below 1700 feet.

Wilsonia citrina (Boddaert). Hooded Warbler. Locally common as a summer resident along the dark hillsides of the southern portion of the region. Arrives April 18 and remains until the last of September.

Wilsonia pusilla pusilla (Wilson). Wilson Warbler. A rather uncommon migrant. I have recorded it from April 29 to May 10. Smith (1915) reported it from May 8 to 13, and again on Sept. 7.

Wilsonia canadensis (Linnaeus). Canadian Warbler. A rare migrant. Smith (1915) collected a single specimen, August 26, 1914. I have one sight record, well substantiated, on May 1, 1927.

Setophaga ruticilla (Linnaeus). American Redstart. Smith (1915) reported this bird as arriving by April 18 and remaining until September 21. I have had little opportunity to observe it except in mid-summer, but found it common in the larger ravines on the southern slope. I have never found it, even in migration, on the north side.

Passer domesticus domesticus (Linnaeus). English Sparrow. Extremely common in the village of Winslow and throughout the country, being abundant around every barn and dwelling. Often builds very bulky nests in trees, sometimes as many as 6 to 8 in a single tree. This overflowing population is in sharp contrast to the condition reported by Smith (1915) in 1914. His statement is quoted in full: "A small number were ever present in the town of Winslow, but the species was of irregular occurrence elsewhere. Roving individuals, sometimes alone, often in small flocks, could sometimes be seen

inspecting barns or outbuildings, even alighting and spending a few minutes in the yard, but eventually departing."

Sturnella magna magna (Linnaeus). Eastern Meadowlark. Perhaps the predominating race in the fall and winter, and rather common throughout November and December, rarer throughout the colder part of the winter. Both *magna* and *argutula* appear to avoid the higher portions of the region.

Sturnella magna argutula Bangs. Southern Meadowlark. The breeding form, rather common especially below 1700 feet. The resident form is very close to *magna*, radically different from specimens collected 50 miles south, but still to be considered closer to the southern than the northern form.

Agelaius phoeniceus phoeniceus (Linnaeus). Eastern Red-winged Blackbird. Fairly common as a migrant and a very rare summer resident. Smith reported a single individual from near the top of the range on Nov. 28, 1914. I have frequently observed it in flocks around Nelson Pond in the fall. Arrives in the spring as early as April 27, and present in small numbers on the extreme lower margin of the region through the summer, greatly augmented by migrants in October, and remaining until early December in small numbers, though mostly gone by the end of the first week in November.

Icterus spurius (Linnaeus). Orchard Oriole. A fairly common summer resident. Arrives by April 22, and eggs have been found in the nest on May 27. Remains in the vicinity, though difficult to find during the last month of its stay, until the last of August.

Icterus galbula (Linnaeus). Baltimore Oriole. An uncommon but regular migrant. Not known to nest within the limits of the Winslow region. Found in the spring from April 20 to May 1.

Euphagus carolinus (Müller). Rusty Blackbird. Migrant and winter visitant. Very irregular in its habits but it has been observed in the spring from April 9 to May 1, as well as occasionally in the winter. Frequently observed in November in flocks around Nelson Pond.

Quiscalus quiscula aeneus Ridgway. Bronzed Grackle. Fairly common migrant and early winter visitant. Recorded in reasonably large numbers in October and November when flocking and roosting with the robins. They always maintained separate flocks but came and went as the robins did and roosted in the same cover. Notes of November 8, 1928 tell of the grackles and robins engaging in battles, the grackles attempting to roost near the robins and the latter resenting their intrusion and driving them away by the effective use of sheer numbers (Bird for bird the grackles proved much the better fighters). The grackles persisted, however, and were often to be found at night roosting in the midst of the robins. The species is also often observed in the spring throughout March and April.

Molothrus ater ater (Boddaert). Eastern Cowbird. Common summer resident, accidental in winter. Arrives after March 22 and common soon thereafter. Smith (1915) did not find them breeding, but they are fairly common now below 1800 feet throughout the summer. Smith has recorded it "several days in November," and again on December 8.

Piranga erythromelas Vieillot. Scarlet Tanager. A common summer resident. Males arrive as early as April 12, the females about a week later. The very evident males seem to be everywhere for a day or so each spring during migration. Although mostly departing in mid-August a few may be found until the first of September.

Piranga rubra rubra (Linnaeus). Summer Tanager. Although not as common as the preceding, either as a migrant or a breeding bird it is fairly common. Arrives as early as April 15 and remains until October 3. Apparently does not travel in such a concentrated migration wave as the preceding species. This bird has been observed quite frequently in this region as a bee catcher, perching near a hive and picking off the bees on the wing much in the manner of the kingbird. Bee keepers have frequently reported the necessity of killing individual birds to protect their hives. I have never examined specimens thus killed to determine the percent of workers to drones taken.

Richmondena cardinalis cardinalis (Linnaeus). Eastern Cardinal. A very common resident, quite typical of the region and abundant throughout the year. Breeds with equal readiness in yards and along small streams and is always one of the most common frequenters of back-yard feed tables in the winter.

Hedymeles ludovicianus (Linnaeus). Rose-breasted Grosbeak. A fairly common spring migrant. Rare in fall. My earliest spring record is April 28. Smith (1915) found it on the 25th. Remains until the middle of May and may be found anywhere in heavy timber, especially along the streams. My only fall record, and apparently the only one for the state, is of a single male observed Oct. 14, 1928, in the very top of a large maple tree in the yard of our residence. This was the same tree in which the warbler wave already mentioned was noticed, and the grosbeak was in the tree for part of the same time the warblers were there.

Guiraca caerulea caerulea (Linnaeus). Eastern Blue Grosbeak. A very rare migrant. Smith (1915) did not record the bird and I have observed it only from May 13 to 23 in 1928. It appeared to be fairly common that one spring.

Passerina cyanea (Linnaeus). Indigo Bunting. A very common summer resident and migrant. Arriving any time between April 19 and May 1, and common thereafter until their departure in mid-September.

Spiza americana (Gmelin). Dickcissel. A rare but regular resident at the lower elevations within the area. Not known above 1650 feet at any season. Locally common about 5 miles north of Winslow along the White River bottom. I have no accurate migration dates for the species.

Carpodacus purpureus purpureus (Gmelin). Eastern Purple Finch. Fairly common as a winter visitant, arriving as early as Nov. 24 and remaining until April 20. A strange case of the nesting of this species here has been previously reported (Black, 1929b).

Spinus pinus pinus (Wilson). Northern Pine Siskin. Recorded by Smith (1915) on March 25 and 26, 1914.

Spinus tristis tristis (Linnaeus). Eastern Goldfinch. A common resident, abundant on occasions in the spring when it congregates in very large flocks.

Pipilo erythrophthalmus erythrophthalmus (Linnaeus). Red-eyed Towhee. A fairly common resident. Considerably more common during the breeding season than in winter.

Passerculus sandwichensis savanna (Wilson). Eastern Savannah Sparrow. A rare migrant. Smith (1915) reports it on only one occasion, April 6, 1914 when he observed several. I have only one record, that of eight individuals in the remarkable migration wave of Oct. 14, 1928.

Ammodramus savannarum australis (Maynard). Eastern Grasshopper Sparrow. A very rare migrant. Smith (1915) reports the taking of two individuals, one on March 23, 1914 (an aberrant specimen then reported as *A. bairdi)* and another on April 4, 1914. I have never seen the bird in Arkansas.

Passerherbulus caudacutus (Latham). Leconte's Sparrow. A very rare migrant, reported only by Smith (1915) on Nov. 29, 1913, May 11, 1913, and myself on March 16, 1930.

Pooecetes gramineus gramineus (Gmelin). Eastern Vesper Sparrow. A rather rare spring migrant. Smith (1915) reports it arriving March 25, in 1914 and remaining for about two weeks. I have found it only on one occasion when two birds spent from April 2 to 5 in our yard in 1927.

Chondestes grammacus grammacus (Say). Eastern Lark Sparrow. A common summer resident. Smith (1915) knew it only from one individual observed April 23, 1914. I have no dates of arrival for it always appears to be nesting when discovered, but it now is a very characteristic bird of the region, especially on the higher plateau region. Apparently another species that has invaded this region within recent years. I first became acquainted with the species in 1928 when two nests were found. It was slightly more common in 1929 and fairly common in 1930, since then to be found almost everywhere, though it prefers elevations above 2000 feet.

Junco hyemalis hyemalis (Linnaeus). Slate-colored Junco. Extremely common winter resident, arriving Oct. 11 or soon thereafter, and remaining until April 18.

Junco oregonus shufeldti Coale. Shufeldt's Junco. A specimen, now in the University of Kansas collection, collected here Jan. 22, 1930, has been identified by Dr. Alden H. Miller as of this form. Another identical specimen taken at the same time was accidentally destroyed. They were taken from a band of individuals at my home, and both were accidentally killed at my banding traps. They always maintained a separate flock from the other Juncos, and were easily differentiated from the other birds in the field. They remained about the place from January 15 until the 10th of February. This constitutes what appears to be the only record of the race from Arkansas.

Spizella arborea arborea (Wilson). Eastern Tree Sparrow. An irregular winter visitant. Smith (1915) recorded a small flock on February 16, 1914. I have one doubtful record from here in January of 1929, and Mr. James informs me that he saw the bird at his home, near Winslow, during the winter

of 1933-34. It should be found more commonly than has proven to be the case.

Spizella passerina passerina (Bechstein). Eastern Chipping Sparrow. A common summer resident, and present throughout the year except from mid-December to about the 17th of March, when it is not to be found. Ordinarily the species leaves the section about the last of October and returns on the 22nd of March.

Spizella pusilla pusilla (Wilson). Eastern Field Sparrow. A common summer resident, a small number remaining here throughout the winter. Perhaps a bit more common than the preceding.

Zonotrichia querula (Nuttall). Harris's Sparrow. Reported by Smith (1915) as an irregular transient. Found by him during the first week of May, 1913 and on Oct. 24 of that year. My only record is of an adult male captured at my home, Jan. 15, 1928 during one of the most severe winters this region has ever known.

Zonotrichia leucophrys leucophrys (Forster). White-crowned Sparrow. Smith (1915) found this species present in large flocks during the first half of May in 1913, but observed it only on May 6 the following year. I have recorded it only on May 15, 1927, as a single bird, and on Dec. 25, 1928, when two birds were seen.

Zonotrichia albicollis (Gmelin). White-throated Sparrow. A very common migrant, wintering in small numbers. Arriving as early as October 20, and remaining as late as May 8. Especially common through the last two weeks of March and the first two weeks of April. Also occurring in large numbers in November.

Passerella iliaca iliaca (Merrem). Eastern Fox Sparrow. Fairly common migrant and a rare winter resident. Present from October 15 until April 1. Considerably more common in fall than in winter and spring.

Melospiza lincolni lincolni (Audubon). Lincoln Sparrow. A rare migrant. I have recorded it on a few occasions from April 29 to May 13. Smith's only record is of an individual collected on September 30, 1914. (Smith, 1915).

Melospiza georgiana (Latham). Swamp Sparrow. Found to be a rare transient by Smith, who recorded it at intervals from April 6 to May 10. I have only a single record, on March 24, 1929.

Melospiza melodia melodia (Wilson). Eastern Song Sparrow. A fairly common winter resident. Smith (1915) recorded it as arriving October 23 and departing toward the end of April, which is correspondent with my dates for the mass movement. The species nest here rarely, however, though the breeding birds are probably of the race *beata*. It is to be regretted that breeding birds have never been collected as they will be needed to determine the presence of the breeding form.

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A TEN YEAR STUDY OF A BIRD POPULATION IN CENTRAL OHIO

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A survey of Ohio ornithological literature discloses a conspicuous scarcity of titles concerning the breeding birds of the state. Most of the papers relating to the summer season are merely annotated local or general distribution lists of breeding species, or records of general observations. Life history studies have been few. However, three splendid studies of a species have been made in the state: the Bald Eagle, along the Lake Erie shore (Herrick and associates), the House Wren near Cleveland (Baldwin and associates), and the Song Sparrow at Columbus (Nice). The writer has made detailed breeding studies of the Great Blue Heron, the Black-crowned Night Heron, the Starling and of four game species, the Ring-necked Pheasant, the Hungarian Partridge, the Bob-White, and the Ruffed Grouse. No great amount of information has been accumulated concerning the other breeding birds, although a total of no less than 179 species are now known to have nested in Ohio.

No Ohio studies have been published concerning the exact breeding bird populations of an area as determined by observations covering a period of years. Although some information has accumulated for individual species, no Ohio data are available concerning the exact nature of the total bird population as influenced by habitat, time or the modification of natural conditions. The amount of time and the sustained effort necessary to complete such a population study covering a period of years, has discouraged field workers from research of this type.

To obtain data concerning the exact make-up and changes of a sample bird population, a detailed study was undertaken from 1924 to 1933 of an 80 acre tract of land near Westerville, 12 miles north of Columbus, Ohio. The area, partially enclosed by a loop of Alum Creek, was chosen because of its accessibility and because it was considered to be fairly typical of stream valley conditions general in Central Ohio and frequent elsewhere in the state. During the study it developed that the area was somewhat superior to the average valley tract in its interspersion and variety of habitat types, its permanent pools of stagnant water, its abundance of food and cover, and its relative freedom from marked environmental changes induced by man or natural influences. During the study 224 bird species were identified on the 80 acres, of which 86 species nested. The average number of nesting species per year was 60.5. The average number of nesting pairs per year was 219.5 or 2.74 pairs per acre. The nesting of 75.8% of the pairs was substantiated by the actual finding of the nest.

The composition of the bird population was fairly constant, but with continuous minor adjustments to environmental changes. More bird pairs nested during the first five year period but more species were present during the second five year period. The number of species nesting each year remained

nearly constant (61 to 66) until the drouth of 1930. The greatest population shifts were due to the effects of the 1930 drouth, with the resultant lowering of the water table, reduced cover and food, and overgrazing. These drouth effects are believed to be chiefly responsible for the reduction from the seven year average of 63 breeding species to only 48 species in 1931. Many species absent in 1931 returned in 1932 and 1933 (totals of 53 and 58).

The ten best represented species with the average number of pairs of each nesting per year, were: English Sparrow, 27.9; Mississippi Song Sparrow, 24.2; E. Red-wing, 23.6; E. Robin, 8.3; Bobolink, 7.7; Northern Yellow-throat, 6 1; Barn Swallow, 6.0; Eastern Cardinal, 4.9; and Alder Flycatcher, 4.8.

Description of the Study Tract

The tract used for study is located in the northwestern corner of Blendon Township, Franklin County, Ohio. Its 80 acres are bounded on the northwest, north and east by Alum Creek, on the south by the Westerville-Worthington Road, and on the west by the western boundary of Blendon Township. The area includes Alum Creek, with several islands, and a strip 25 feet wide on the outside bank of the loop of the stream. The area is usually divided into 15 to 20 small fields so that an unusual interspersion of crops is obtained. A considerable portion of the pond and bottomland area has been little disturbed. The usual crop rotation is corn-wheat-meadow- pasture, although considerable variation occurs on the small plots and potatoes and garden crops are often grown. Much of the fencing until recently has been of osage orange hedge. Two farmhouses, two barns, a cottage, and the water supply plant of Westerville, comprise the buildings.

In the lower bottomland areas adjacent to Alum Creek, several former channels of that stream are in evidence. Nearly two miles of dikes (3 to 15 feet high) have been built in the past to control water flow. These are covered with a sod of blue grass and weeds, providing excellent nesting sites for the Song Sparrow and several other ground nesting species. As indicated on the map, seven small ponds occur as a result of a former mill race and channels cut across the neck of the Alum Creek loop. Ponds No. 1, 3, 4 and 5, formerly permanent or nearly so, are now usually dry during the breeding season. Formerly the homes of rail and redwings, they are now mostly covered with sedges, crack willow, cottonwood and osage orange or rose thickets. Ponds 2, 6 and 7, comprise the largest cattail swamp in Franklin County. Number 7 is the largest, having deep channels alternating with low islands covered with cottonwoods, crack willow and pussy willow thicket. This pond was the only one to retain any water during the 1930 and 1934 drouth years. The map indicates that most of the stream banks, the pond area, the dikes and many of the fencerows, have a cover of woody plants. Many of those along the stream are large trees. Elsewhere most of the tree growth is from 10-40 feet in height, with much thicket of crackwillow, wild rose, elm, box elder and pussy willow. The common woody plants in the approximate order of abundance are: white elm, crack willow, black willow, osage orange, common elderberry, cottonwood, box elder, hackberry, black locust, buckeye, sycamore, pussy willow, prairie wild rose, wild apple and hawthorne, black cherry,

black walnut, basswood, honey locust, white ash, black raspberry, blackberry, sugar maple, bladdernut, prickly ash, buttonbush, bitternut, biltmore ash, butternut, shagbark hickory, ninebark and black maple. Several vines are also abundant: Virginia creeper, poison ivy, wild grape and bittersweet.

In the swampy areas more than 20 species of sedges abound. In addition to broad-leaf cattail, common rush *(Juncus effusus)*, moneywort and arrowhead, cover extensive areas. In the undisturbed bottomland occurs a rank growth (2-8 feet high) of giant ragweed, Indian-cup, purple-stemmed angelica, cow parsnip, wild rye, elderberry, box elder, wild sunflowers, golden rod and asters. Alum Creek is choked at a dozen riffles with a dense growth of water willow. Along the stream banks are small patches of most of the woodland flowers of the region. The flora of both native and introduced plants is remarkably varied considering the size of the area. A careful survey of the higher or vascular plants of the area showed that no less than 362 species occur, including several collected for the state herbarium and reported for the first time for Franklin County and central Ohio.

Methods of Study Used

Before the first nesting season began the area was very carefully surveyed in great detail and mapped. All natural features were evaluated with respect to the bird population, and the general plan of the work outlined so that the methods used would be strictly comparable for each of the ten years. During the first, third, fourth and fifth breeding seasons, the area was visited daily from April 10th to June 12th, for two or more hours each day, including repeated before sunrise censuses of the singing males. Observations later in the day made it possible to map the territories and the approximate nest location of each breeding pair. In most years nearly all of the nests were actually located except for some of the ground nesting species. The work was done in such detail that it seems almost impossible that a single breeding species could have been missed. The numbers of pairs given for each species each year is believed to be exact except for two or three numerous species (example Song Sparrow) where it was difficult to work out the exact territories and eliminate non-breeding individuals, in the time available.

In some cases late arrivals, early or late nesting pairs, destruction of nests, or movements to or from the area, presented complicated problems which usually could be unraveled with sufficient study though in only a few cases was it possible to band the birds in question. The table does not list nests of second broods, second attempts, or of pairs which moved on to the area after an attempt elsewhere. The table lists as nearly as it could be determined by repeated observations, the number of *breeding* pairs of each species present on the area during the main breeding season for the species in question. Though the main observations extended to June 12 (a date well past the height of the nesting season), later checks were made on late nesting species such as the Goldfinch and Cedar Waxwing.

During the other six years of the study the area was visited once or twice weekly from April 10 to June 12, or more frequently if necessary to work

out the necessary breeding data. During the remainder of the year visits were made from 2 to 10 times each month, and a record kept of the spring and fall transients and the winter visitors. During the winters of 1925-26, 1926-27, 1927-28 and 1930-31, winter feeding stations were maintained on the area which attracted a total of 24 species. During 125 months of records, 224 species were observed within the limits of the 80 acres.

The total list for each month was as follows:

January	49	July	80
February	62	August	89
March	79	September	117
April	136	October	122
May	172	November	91
June	96	December	58

A number of bird skins and of egg sets from the area are now preserved in the Otterbein College Museum, the Ohio State Museum, or in the collection of Mr. Charles F. Long of Columbus. Some of the rarer species recorded were Eastern Goshawk, Pigeon Hawk, Bald Eagle, Yellow Rail, Black Rail, Purple Gallinule (collected May 17, 1927 for the Ohio State Museum), Saw-whet Owl, Olive-sided Flycatcher, Orange-crowned Warbler, Connecticut Warbler, White-winged Crossbill, Nelson's Sparrow, and Snow Bunting. The total list of species recorded is of too great length and of insufficient importance to be included here. Migrant records from the area have been incorporated in the records of the Wheaton Club of Columbus. These are published elsewhere and a copy filed with the United States Biological Survey.

In this paper, only the common names of bird species are given for the sake of brevity, as both the order and nomenclature used are that of the standard established by the American Ornithologists' Union Check-list of 1931.

Analysis of Population

In addition to the 86 species which have nested on the 80 acre tract studied from 1924-1933, ten others are known to breed within three miles of the area concerned. These are: Turkey Vulture, Eastern Red-tailed Hawk, Northern Red-souldered Hawk, European Partridge, Great Horned Owl, Northern Barred Owl, Eastern Whip-poor-will, Yellow-throated Vireo, Cerulean Warbler, and Louisiana Water-thrush. Other species known to nest or to have nested formerly elsewhere in Franklin County include: Pied-billed Grebe, Great Blue Heron, Common Mallard, Wood Duck, Lesser Scaup, Sharp-shinned Hawk, Eastern Turkey, Florida Gallinule, American Coot, Eastern Nighthawk, Short-billed Marsh Wren, White-eyed Vireo, Black and White Warbler, Prothonotary Warbler, Worm-eating Warbler, Sycamore Warbler, Summer Tanager, Eastern Savannah Sparrow, Eastern Lark Sparrow, and Bachman's Sparrow. These 21 additions bring the Franklin County list of breeding species to 117. The number of species known to have nested in all of Ohio is 179. Thus the 80 acre tract during the ten years supported

as breeding birds 73.5% of the species known to breed in Franklin County and 48.0% of the species known to nest in Ohio.

Fifty-nine or 68.6% of the species and 1912 or 87.1% of the pairs nesting, were passerine species. Thirty-nine species or 45% of the total number, nested on the area during each of the ten years. If this is a typical case, we can generalize that only about half of the species breeding on a 100 acre tract during a decade will nest every year. Four species were present 9 years, 5 species 8 years, 6 species 7 years, 5 species 6 years, 3 species 5 years, 5 species 3 years, 6 species 2 years and 8 species 1 year. Sixty-two species or 72%, nested during at least half of the years. Species nesting only one year were Eastern Least Bittern, Common Black Duck, (the female was wing-tipped), Eastern Mockingbird, Blue-grey Gnatcatcher, American Redstart, Orchard Oriole, Scarlet Tanager and Dickcissel.

The numbers of several species were remarkable constant. A single pair each of the Screech Owl, White-breasted Nuthatch and Baltimore Oriole, nested each year. Two others, the Crested Flycatcher and the Downy Woodpecker, were present each year, yet never in excess of one or two pairs each. Man, by the destruction of nesting sites, was responsible for the elimination of five breeding species during the period: Barn Owl, Bank Swallow, Purple Martin, Cliff Swallow and Sparrow Hawk. He was indirectly responsible for the disappearance of three others due to the lowering of water levels: the King Rail, the Virginia Rail and the Marsh Hawk.

Thirty-six species nested in greater numbers during the first five year period and 39 species were better represented during the second five year period. Eleven species were equally divided between the two periods. Seventy species nested from 1924-1928 and 74 from 1929-1933. There was considerable evidence that the area gradually became less attractive to species of large size, to aquatic species, and to several of the rarer species restricted to unusual habitats. On the other hand, the tract appeared to become increasingly attractive to most of the smaller passerine species.

A study of this type uncovers considerable data as to what environmental factors have been most important in the past in affecting the development of the bird populations of today. It also makes it possible to predict what is likely to happen in the future and as to which environmental factors will be most important in shaping the bird population of tomorrow. On the tract studied the future of the bird population will be determined almost entirely (either directly or indirectly) by the activities of man. Some of the most important influences likely to operate are:

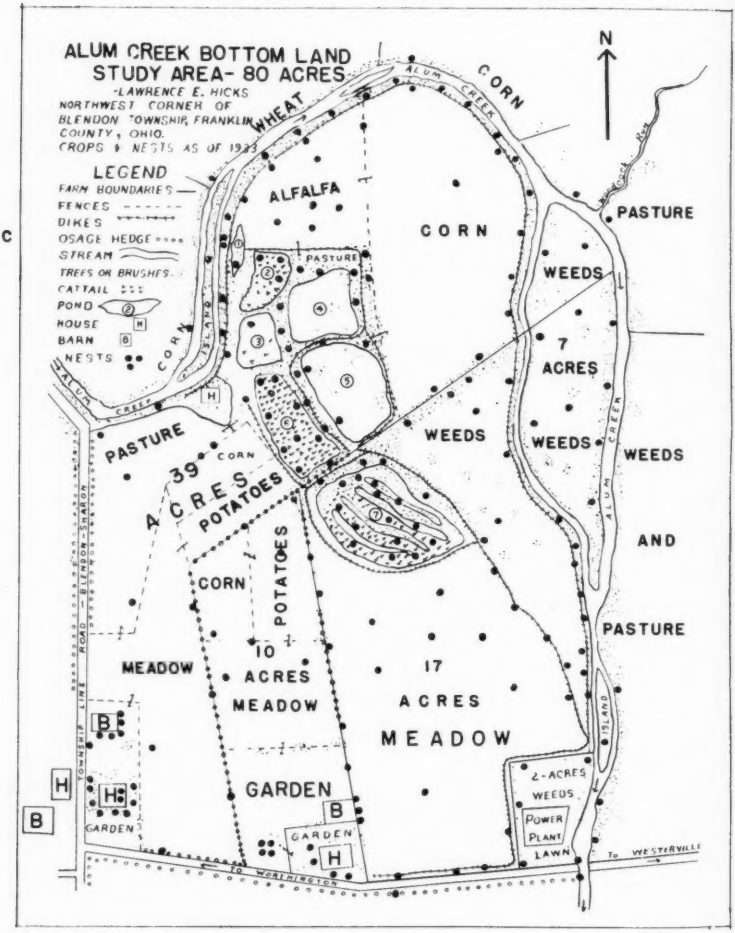
1. Further lowering of the water table and drainage of ponds.
2. Cultivation of a larger percent of the total acreage.
3. Over-pasturing.
4. Cutting of the woody stream bottom vegetation.
5. Spring and autumn burning of dry vegetation.
6. Destruction of osage orange hedges.
7. Destruction of fencerow vegetation and intensive or "clean" agricultural practices.
8. Roadside mowing.
9. Union of several fields into one large field resulting in less interspersion of habitat types.

During the winter of 1933-34, as elsewhere in the country, a squad of unemployed laborers was assigned to "clean up" a portion of this bottomland tract. Several of the changes listed above were brought about to a marked degree, with very drastic effects as reflected in the 1934 breeding bird population. Fortunately most of the affects produced are of a temporary nature. If the area is left relatively undisturbed again and the normal water levels return with increased rainfall, we may expect the bird population of the coming decade to be essentially the same as that of the last.

Species	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	Years Present	Nests located	Breeding Pairs
1 E. Green Heron	1	1	1	2	1	1	1	0	1	1	9	9	10
2 E. Least Bittern	0	0	0	1	0	0	0	0	0	0	1	1	1
3 C. Black Duck	0	0	0	1	0	0	0	0	0	0	1	1	1
4 Cooper's Hawk	0	1	0	0	0	1	0	0	0	0	3	3	3
5 Marsh Hawk	1	0	0	0	0	0	0	0	0	0	2	2	2
6 E. Sparrow Hawk	1	1	1	1	0	0	0	0	0	0	4	4	4
7 E. Bob-white	4	3	2	1	2	3	4	5	5	5	10	18	34
8 Ring-neck Pheas'nt	1	0	1	0	1	1	0	1	1	1	7	6	7
9 King Rail	1	1	2	3	1	0	0	0	0	0	5	8	8
10 Virginia Rail	0	0	1	1	0	0	0	0	0	0	2	2	2
11 Killdeer	3	2	1	2	1	4	3	2	1	2	10	15	21
12 Am. Woodcock	1	2	0	1	0	1	1	2	0	1	7	5	9
13 Upland Plover	1	0	1	0	0	0	1	1	1	0	5	3	5
14 Spotted Sandpiper	0	1	1	1	1	2	1	0	1	1	8	4	9
15 E. Mourning Dove	4	3	2	4	3	3	4	5	4	3	10	34	35
16 Yellow-bill Cuckoo	2	1	1	1	1	2	2	1	2	2	10	12	15
17 Black-bill Cuckoo	0	0	0	1	0	0	0	0	1	1	3	3	3
18 Barn Owl	1	1	1	1	1	1	0	0	0	0	6	6	6
19 E. Screech Owl	1	1	1	1	1	1	1	1	1	1	10	8	10
20 Chimney Swift	2	1	2	2	1	2	2	2	1	2	10	15	15
21 Ruby-thr. Hummingbird	1	1	0	1	1	0	1	0	1	1	7	4	7
22 E.Belt. Kingfisher	1	1	1	1	1	0	0	0	0	1	6	6	6
23 Northern Flicker	3	4	2	3	1	2	1	2	2	3	10	23	23
24 Red-bel.W'dpeck'r	0	1	1	1	0	0	0	0	0	0	3	3	3
25 Red-h'd.W'dpeck'r	4	3	2	4	2	3	2	2	1	2	10	25	25
26 E.Hairy W'dpeck'r	1	1	1	0	1	1	1	0	1	0	7	7	7
27 N. Downy Woodpecker	1	1	2	1	1	1	2	1	1	1	10	8	12
28 E. Kingbird	1	1	1	1	0	0	1	0	0	1	6	5	6
29 N. Cr. Flycatcher	1	2	1	1	1	1	1	1	1	1	10	7	11
30 E. Phoebe	4	5	3	4	3	2	4	3	2	2	10	32	32
31 Acad. Flycatcher	0	0	0	1	1	0	0	0	0	0	2	1	2
32 Alder Flycatcher	5	4	6	6	7	5	4	4	5	2	10	44	48
33 E. Wood Pewee	3	2	3	3	2	2	3	4	5	3	10	12	30
34 P. Horned Lark	0	0	0	0	1	1	0	0	0	0	2	1	2
35 Bank Swallow	8	6	7	0	0	0	0	0	0	0	3	21	21
36 Rough-wg.Sw'llow	2	3	2	2	4	3	6	2	3	2	10	29	29
37 Barn Swallow	6	7	8	9	6	8	7	4	3	2	10	60	60
38 N.Cliff Swallow	0	0	0	0	2	2	0	0	0	0	2	4	4
39 Purple Martin	4	3	5	6	4	0	0	0	0	4	6	26	26

Species	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	Years Present	Nests located	Breeding Pairs
40 N. Blue Jay	2	1	1	2	2	3	2	2	1	1	10	13	17
41 E. Crow	2	1	1	2	1	2	2	2	2	1	10	15	16
42 Car. Chickadee	1	1	1	2	1	0	1	1	0	0	7	6	8
43 Tufted Titmouse	1	1	2	1	1	2	1	2	2	2	10	7	15
44 W. Br. Nuthatch	1	1	1	1	1	1	1	1	1	1	10	9	10
45 E. House Wren	3	2	2	2	3	2	3	3	3	2	10	20	25
46 Bewick's Wren	0	0	0	0	1	1	1	0	0	0	3	3	3
47 Carolina Wren	3	2	4	3	2	3	4	3	2	2	10	10	28
48 Pr. Marsh Wren	2	3	2	1	0	0	0	0	2	2	6	12	12
49 E. Mockingbird	0	0	0	0	0	1	0	0	0	0	1	1	1
50 Catbird	4	6	7	4	3	4	5	5	5	6	10	35	49
51 Brown Thrasher	1	1	2	1	1	1	1	0	0	1	8	16	17
52 E. Robin	8	7	6	10	9	11	8	9	8	7	10	83	83
53 Wood Thrush	1	0	0	1	0	0	1	0	0	1	4	4	4
54 E. Bluebird	2	3	4	3	4	3	3	2	1	1	10	26	26
55 Blue-gr. Gnat-catcher	0	0	0	0	0	1	0	0	0	0	1	1	1
56 Cedar Waxwing	1	0	2	0	3	2	0	1	2	2	7	13	13
57 Migrant Shrike	1	1	1	0	0	0	1	0	0	1	5	5	5
58 Starling	1	0	1	0	1	2	1	3	2	3	8	14	14
59 Red-eyed Vireo	1	1	1	1	2	1	0	1	1	2	9	7	11
60 E. Warbling Vireo	1	1	1	0	1	1	1	0	1	2	8	4	9
61 Blue-wg. Warbler	0	0	0	1	1	1	1	0	0	0	4	2	4
62 E. Yellow W'bler	0	1	2	1	2	3	2	1	1	2	9	8	15
63 Ovenbird	0	0	0	1	1	1	1	0	0	0	4	2	4
64 N. Yellow-throat	4	6	7	6	7	8	7	5	6	5	10	11	61
65 Yellow-br. Chat	0	0	0	1	1	1	1	1	1	2	8	5	7
66 Am. Redstart	0	0	0	0	1	0	0	0	0	0	1	1	1
67 English Sparrow	37	48	34	28	24	20	22	21	29	16	10	279	279
68 Bobolink	8	7	6	5	11	12	14	5	2	7	10	14	77
69 E. Meadowlark	4	5	6	4	2	7	5	6	2	3	10	21	44
70 E. Red-wing	18	21	29	27	29	34	26	12	17	23	10	164	236
71 Orchard Oriole	0	0	0	0	0	1	0	0	0	0	1	1	1
72 Baltimore Oriole	1	1	1	1	1	1	1	1	1	1	10	10	10
73 Bronzed Grackle	2	3	4	5	4	3	2	0	1	2	9	26	26
74 Cowbird	3	4	7	5	4	7	6	5	4	3	10	105*	48
75 Scarlet Tanager	0	0	0	1	0	0	0	0	0	0	1	1	1
76 E. Cardinal	6	5	6	4	6	6	5	4	5	3	10	38	50
77. Indigo Bunting	3	4	3	4	4	4	3	2	3	3	10	15	33
78 Dickcissel	0	0	0	0	0	1	0	0	0	0	1	0	1
79 E. Goldfinch	4	3	2	2	1	2	3	2	3	4	10	13	26
80 Red-eyed Towhee	0	0	0	0	0	1	1	0	0	0	2	1	2
81 E. Grasshopper Sparrow	1	2	3	2	1	3	4	2	2	2	10	8	10
82 W. Henslow's Sparrow	0	0	0	0	0	2	2	0	0	0	4	1	2
83 E. Vesper Sparrow	1	1	1	2	1	2	1	3	2	1	10	6	15
84 E. Chipping Sparrow	2	3	2	3	2	4	3	4	1	2	10	18	26
85 E. Field Sparrow	4	3	5	4	3	7	6	5	3	6	10	20	46
86. Mississippi Song Sparrow	21	20	24	18	28	33	31	23	17	27	10	142	242

* Number of nests of other species in which resident cowbirds had deposited eggs.


ALUM CREEK BOTTOM LAND
STUDY AREA- 80 ACRES
-LAWRENCE E. HICKS
NORTHWEST CORNER OF
BLENDON TOWNSHIP, FRANKLIN
COUNTY, OHIO.
CROPS & NESTS AS OF 1929
LEGEND
FARM BOUNDARIES
FENCES
DIKES
OSAGE HEDGE
STREAM
TREES OR BRUSHES
CATTAIL
POND
HOUSE
BARN
NESTS
N
WHEAT
CORN
ALFALFA
PASTURE
CORN
WEEDS
7 ACRES
WEEDS
WEEDS
WEEDS
AND
PASTURE
PASTURE
39 ACRES
CORN
POTATOES
CORN
POTATOES
10 ACRES
MEADOW
MEADOW
17 ACRES
MEADOW
GARDEN
GARDEN
GARDEN
2-ACRES
WEEDS
POWER PLANT
LAWN
ALUM CREEK
ISLAND
CORN
TO WORTHINGTON
To WESTERVILLE
TOWNSHIP LINE ROAD - BLENDON - CLINTON

SUMMARY

	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Species present	64	61	63	66	65	64	61	48	54	59
% of total species present each year	74.4	70.0	73.3	76.7	75.6	74.1	70.0	56.0	62.7	68.6
No. nesting pairs	225	233	245	227	222	258	239	179	177	194
No. nests located	198	191	202	198	182	186	150	121	125	113
No. of bird pairs per acre	2.81	2.91	3.06	2.84	2.77	3.22	2.99	2.24	2.21	2.42

Breeding species present, 10 year period (1924 to 1933) ---------- 86
Total species recorded (1924-1933) ---------- 224
Total breeding pairs (1924 to 1933) ---------- 2195
Total nests located (species) ---------- 85
Total nests located (number) ---------- 1664
Average number of species present per year ---------- 60.5
Average number of nesting pairs per acre ---------- 2.74
Average number of nesting pairs per year ---------- 219.5
Species present first five year period (1924 to 1928) ---------- 70
Nesting pairs first 5 year period (230 per year) (2.98 per acre) Total number 1152
Species present second five year period (1929 to 1933) ---------- 75
Nesting pairs second 5 yr. period (209 per year) (2.61 per acre) Total number 1045

The 27 most numerous nesting species, with the average number of nesting pairs each per year, were as follows:

English Sparrow	27.9	E. Bob-white	3.4
Mississippi Song Sparrow	24.2	Indigo Bunting	3.3
E. Red-wing	23.6	E. Phoebe	3.2
E. Robin	8.3	E. Wood Pewee	3.0
Bobolink	7.7	Rough-winged Swallow	2.9
N. Yellow-throat	6.1	Carolina Wren	2.8
Barn Swallow	6.0	Purple Martin	2.6
E. Cardinal	5.0	E. Chipping Sparrow	2.6
Catbird	4.9	Bronzed Grackle	2.6
Alder Flycatcher	4.8	E. Bluebird	2.6
Cowbird	4.8	E. Goldfinch	2.6
E. Field Sparrow	4.6	Red-headed Woodpecker	2.5
E. Meadowlark	4.4	E. House Wren	2.5
E. Mourning Dove	3.5		

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HABITS OF JUMPING MICE

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Little has been accomplished toward making a comprehensive life history study of our jumping mice. The following notes, gathered by the writer over several seasons' observation of these creatures, are given primarily to stimulate further studies into the habits of these interesting forms. Much may perhaps be known, but little has been published, on the habits of American Zapodids.

In New York State, where the majority of the following notes were made, we have two widely distributed genera, *Zapus* and *Napoezapus*. The former has two subspecies, *Zapus h. hudsonius* (Zimmerman), that covers most of New York, including the open meadows of the heavily forested Adirondack region, while on Long Island and the lower Hudson Valley, a smaller, paler form, *Zapus h. americanus* (Barton), occurs. *Napaeozapus insignis insignis* (Miller), a much brighter animal than *Zapus*, may be further differentiated by the white tail tip, usually present. It is the handsomest of eastern forest mammals.

In the following account, the two genera are treated together, by way of comparing their habits. Because of the diverse habitat usually chosen by the two groups, it seems best to treat of them in this manner.

Measurements and Weights

(Adult specimens from Central New York)

Napaeozapus insignis insignis

25 males			20 females		
Total length	Tail	Hind foot	Total length	Tail	Hind foot
226.6	140.7	30	228.7	138	30.5
(249-210)	(152-127)	(32-28)		(150-126)	(34-28)

May-June weights		Sept.-Oct. weights	
25 males	15 females*	6 males	5 females
19.9 gms.	20.7 gms.	26.8 gms.	25.3 gms.

Zapus hudsonius hudsonius

10 males			12 females		
Total length	Tail	Hind foot	Total length	Tail	Hind foot
212	128	30.8	215	128.6	31.1
(215-208)	(130-126)	(32-30)	(221-210)	(135-120)	(32-28)

May-June weights		Sept.-Oct. weights	
4 males	5 females[1]	7 males	4 females
16.5 gms.	15.4 gms.	21.6 gms.	20.6 gms.
(17-15.2)	(17-14.1)	(26-18.7)	(23-1-17)

From the foregoing figures it may be seen that *Zapus* is in every way, with the exception of the hind feet, a smaller animal. The weights particularly bear this out, but show that *Napaeozapus* is not twice as heavy as *Zapus*, as Saunders has suggested.

[1] Females in advanced pregnancy not included in weights.

General Habits

The habitats occupied by the two genera of jumping mice differ somewhat. *Napaeozapus* is found, for the most part, in forests, boreal swamps and Canadian Zone pockets. It apparently demands a nearby stream for its choice. A splendid colored picture of a typical habitat of *Napaeoztnus,* Buttermilk Falls, near Ithaca, New York, is shown in the upper figure of Plate 12, in the National Geographic Magazine for November, 1933. Mice have been recorded from this identical spot, shown at the top of the falls. Not all are addicted to a home in the woods. An individual was seen at Pascoag, Rhode Island, in late June, 1928 in a little swamp bordered with alder and willow. This is not far from the coastal strip, with its associated austral affinities. *Zapus,* on the other hand, is an inhabitant of the open meadows and grasslands, but the ranges of the two animals overlap in the same locality. It is not unusual to meet with *Zapus* in *Napaeozapus* territory, at least in central New York. The converse does not appear to hold.

Jumping mice, in spite of many statements to the contrary, are locally abundant, and may even be among the most numerous of small mammals in certain places. The following records will testify to such a statement.

On June 11, 1932 I commenced trapping in a little Canadian Zone pocket, thirteen miles east of Ithaca, New York, at an elevation of 1400 feet. The first night sixty traps (Burt can traps and Sherman metal box traps) were set and increased in a few days to ninety. In this area the breeding birds were Canadian and black-throated green warblers, juncos, grouse, and woodcock. Among the larger dominant vegetation may be mentioned *Tsuga, Acer pennsylvanicum, Carpinus, Betula lenta* and *B. lutea, Hicoria, Pinus strobus, Populus grandidentata* and *P. tremuloides, Alnus incana, Viburnum alnifolium* and *Hamamelis.* The ground cover consisted for the most part of *Aralia nudicaulis, Tiarella, Chrysosplenium americanum, Mitella diphylla, Streptopus, Trillium undulatum* and *T. erectum, Oakesia, Caulophyllum, Desmodium* sp. *Mitchella, Botrychium virginianum* and *B. lanceolatum, Viola rotundifolia, Trientalis, Aralia racemosa, Pyrola, Geum, Cypripedium acaule, Clintonia, Equisetum sylvatica, Aquilegia, Podophyllum,* and *Epigaea.* In the little openings that permitted direct sunlight to play, wild raspberries, both *Rubus aculeatissimus* and *R. occidentalis,* flourished and here various species of mice repaired to feast when the fruit matured.

In this little haven, scarce half a mile long, and not more than fifteen yards on either side of the little brook that tumbled through it, the traps took, in twenty nights, 86 *Blarina,* 51 *Napaeozapus,* 17 *Sorex,* 8 *Tamias,* 7 *Peromyscus,* 2 *Clethrionomys* and 1 *Condylura.* These traps are not as sensitive as the small snap-back affair, that kills the animal. If such a type had been used, and the animals collected as dead specimens, fully twice the number would undoubtedly have been taken. Thus we have half a hundred of the supposedly rare *Napaeozapus* taken in an area encompassing but 75,000 square feet. Of course small mammals roam widely, and many from outside the boundaries of the trap line were doubtless taken in the total catch. But many remained in the

area, for the last few night of trapping yielded greater numbers than did the early week of collecting.

To determine, if possible, any annual fluctuation in the numbers of this mouse, about eighty traps were placed in the same locality from June 11 to June 24, 1933. Fifty-seven were collected, six more than the previous June and in a considerably shorter period. In one night eleven were captured. Five *Napaeozapus* were taken in two nights of trapping in June, 1934. Apparently the mice were as abundant as in former years.

Similarly, while collecting small mammals in June, 1928 in northwestern Connecticut, I found small mammals very scarce, but succeeded in securing greater numbers of *Napaeozapus* than any other genus, not excepting *Peromyscus* and *Blarina*. Mr. Hiram Beebe of Canaan, Connecticut informed me that the previous winter weasels had been very abundant, twenty times the normal catch being reported. While the trader's figures may have been unduly high, might not this influx of weasels into the area have so lessened the number of forms that are normally active in the winter that the hibernators actually became more abundant than their less favored kindred?

Zapus is not uncommon in favorable situation. Edward Drake of Ithaca, New York, saw ten, one of which he caught, in a two-acre field while haying July 11, 1933. During mid-May, 1927 while leading a class of twenty students through a low piece of ground thickly grown to skunk cabbage near Ithaca, New York, we saw three of these mice within a rod of each other.

After jumping mice once emerge from hibernation in the spring, like the woodchuck, cold snaps and inclement weather appear to have little effect on them.

An insistent rain and a temperature of 40° Fahrenheit on June 14, 1932 did not prevent four *Napaeozapus* from entering my traps. On June 24, 1932 the temperature dropped to 38° Fahrenheit. In spite of the chill night, two *Napaeozapus* were taken, and to judge from the numerous droppings in many of the can traps, mice were very active during the night. Similar cold spells during June, 1933 did little to keep the mice inactive. As a matter of fact, my catches were larger on disagreeable stormy nights than they were on clear fair evenings.

There is some indication that *Napaeozapus* run in pairs, at least during June. Two traps were set side by side, in a number of situations, after evidence of this nature was suggested by the early catches. By June 20, 1932 I had several times caught two mice of opposite sex in adjoining traps. June 23, 1932 six were collected, and these were in pairs of opposite sex, each pair in closely adjoining traps. Using the small snap-back type of trap earlier in the season, I found the same situation to prevail.

On one occasion, a *Napaeozapus* was found caught between the edge of the wire mesh and the opening of the can, in a Burt trap.[2] I was astonished to find, on removing the mouse, an unharmed *Peromyscus* within the can.

2 The Burt trap is described in Journ. Mamm. 8:302. 1927.

Did the deer mouse enter first, and frighten out the jumper as it entered, which in its rush to escape, sprung the trap? Or is it customary for these widely separated genera to resort freely with one another, taking food from the same table.

The powers of jumping have been recorded by various writers. Merriam ascribes to *Zapus* the ability to jump more than ten feet, while Snyder speaks of a *Napaeozapus* that took a normal leap of seven feet. When disturbed from its nest during the morning this latter mouse made estimated leaps of from ten to twelve feet. I think we may well consider these the maximum leaps for the two species, although early writers, probably exaggerating, credited *Zapus* with four- and five-yard leaps. My own observations, on frightened *Napaeozapus*, indicate they do not average more than four to six feet, and usually a jump half this distance is the normal thing. I have seen both species make short leaps of from twelve to twenty inches, in an effort to gain cover. Frequently they run under cover of short grasses, or convenient clods or dirt, brush, or other obstacles to avoid detection.

Both species swim well, and can remain in the water, swimming strongly, for four or five minutes, perhaps longer. They swim not unlike other true mice, except that the head is held higher and the tail arched near its middle. The fore feet are not employed, but the hind limbs are of primary importance to the swimming mouse.

The scansorial powers are well developed. In my outdoor enclosures, limbs and brush were placed, and the mice ran over these without hesitation. Probably they climb the vines of *Rubus* during the summer. It is certain they eat the berries of this plant in the wild state.

Jumping mice do not have well defined runways like those of *Microtus* and certain other small rodents. Yet *Napaeozapus*, which has a more restricted habitat than *Zapus*, apparently follows certain well defined paths. Traps set along the narrow borders of small brooks, bounded by banks several inches to several feet in height, and at the immediate edge of such banks, yield the larger numbers. Night after night traps in such places rewarded the collector, while those set several feet from the edge of the bank failed to make catches in any appreciable numbers. Jumping mice do not resort to the subterranean burrows of *Blarina*, tunneled through the leaf mold, and so frequently occupied by other small mammals.

That these mice can and do dig is not to be doubted. The entrance to the tunnels of *Napaeozapus*, frequently exposed on the slopes of little streams, are easily opened. Only rarely is the globular nest of leaves found, about the size of a small grapefruit. The nests of *Zapus* are in the open meadow, either on the surface, in a tussock of grass or a few inches below the ground surface and covered by a protecting log. The nests are made of material found in the immediate vicinity. I have seen such nests composed entirely of the dead leaves of herbaceous plants.

Among their enemies, owls probably account for the largest toll. A. K. Fisher found many *Zapus* skulls in barn owl pellets at Washington, D. C.

Several species of hawks eat them. Mink have been reported feeding upon them by Dearborn (1932, p. 32). I once found two *Napaeozapus* in the stomach of a November-caught skunk. There is as yet no positive evidence that foxes eat them, but undoubtedly such is the case. Surface (1906, p. 197) records *Zapus* from the stomach of a rattlesnake.

Jumping mice are not as much subject to external parasites as other small rodents, yet a *Napaeozapus* yielded several fleas, *Ctenophthalmus pseudagyrtes* (Baker), that likewise finds a host in *Peromyscus*, *Microtus* and *Parascalops*. A louse was once taken from *Zapus*.

Entrance into Hibernation

Zapus.—Most observers credit jumping mice with entering upon their winter sleep earlier in the season than this periodic phenomena usually begins. It is not uncommon to secure these animals after several heavy frosts have occurred. A female collected October 11, 1924, was very fat. Edward Drake saw one on October 19, 1933 near Ithaca, New York. A freshly killed adult male with part of the head gone, was found in a pool east of Ithaca, New York, on November 13, 1931. A. A. Allen trapped two on November 18, 1909, after a slight snowfall and considerable freezing weather had occurred.

Napaeozapus.—We have few fall records for this genus. A young female was collected on September 22, 1932 by the writer near Ithaca, New York. A. L. Rand informs me he took five at Lake Placid, New York, high in the Adirondacks on the 24th and 25th of September, 1932. These were not at all fat.

The late seasonal activities of captives, in spacious outdoor enclosures, would argue for an entrance into hibernation toward the middle to the latter part of November.

In a large outdoor enclosure, with an area 14 square feet for the mice to run over, an exercise wheel and two inches of sandy loam over the bottom, 13 mice were liberated during the summer of 1932. These were marked in various ways, by excising a toe, clipping an ear, etc., so that individuals would be recognized at a later date.

All were active on the night of October 14, although the temperature dropped to 29° Fahrenheit and the cold weather was accompanied by a heavy frost. On November 2, water froze hard; yet the jumpers were active. On November 21, after the temperature dropped to 20° Fahrenheit two nights previously, several of the mice were out in the enclosure. November 24 the temperature dropped to 12° Fahrenheit, yet a stub-tailed mouse was out of its nest box, apparently gathering food. After this date none made their appearance regularly, although one or two individuals were active throughout the winter.

An adult male, caught by the tail in the trap in mid-June, was inadvertently freed in my yard after the tail had been amputated perhaps an inch from the body. I found this animal dead near a small pile of wood within 100 feet of its point of release on December 23. It had apparently been dead

but a few days and was extraordinarily fat, weighing 31 grams. It had either emerged from hibernation or had not sought shelter at this late date. It is of interest to note that such a stub-tailed animal so handicapped, should have survived for more than half a year.

The Hibernation Period

In general, jumping mice seek a retreat from a few inches to several feet below the ground surface, where a nest is constructed of leaves, grass or any satisfactory and available material. Possibly they dig deeper in the northern parts of their range than in the southern sections.

Barton (1799, p. 122 writing on the hibernating habits of *Zapus*, tells us:

> That gardeners in the Philadelphia region uncovered these animals at a depth of eighteen inches or two feet, when they had ben digging for the roots of horse-radish and parsley, in winter-time. . . . Does it use these (horse-radish and other perpendicular roots) as a measure of the distance to which it shall go in the earth, to avoid the influence of frost?

Tenney (1872, p. 330), writing of a mound near Vincennes, Indiana that he examined on January 18, 1872, says:

> While digging in the mound. . . we came to a nest about two feet below the surface of the ground, carefully made of bits of grass, and in this nest was a Jumping Mouse (*Jaculus Hudsonius* Baird) apparently dead. It was coiled up as tightly as it could be, the nose placed upon the belly, and the long tail coiled about the ball-like form which the animal had assumed.

Jumping mice are frequently found in pairs in the hibernating chamber. Kennicott (1856, p. 96) writes that:

> Dr. Hoy informs me that, when he was a boy. . . in digging out a rabbit in winter, he found a pair of this species (*Zapus hudsonius*) in a state of profound torpor, exhibitiing all the phenomena of profound hibernation. They were in a large nest of leaves situated two or three feet below the surfac.

Mr. Charles Van Fleet of Perry City, New York, who is a keen observer of wild life, tells me that several years ago (about 1927, he thinks) while he and a neighbor were digging in a gravel pit, he came upon two *Zapus*. They were not in a nest, and were several feet apart, but, of most interest, no discernible burrow led to their retreat. They were nearly four feet from the ground surface, as Van Fleet remembers.

Jumping mice do not always resort to such deep quarters for their winter somnolence. Preble (1915, p. 9) writes:

> Dr. A. K. Fisher tells me that some years ago a *Zapus* was brought to him at Lake George, New York, which some men at work in the woods had found hibernating in an elaborate nest of grass, and moss, exposed by moving a log.

What of the hibernating place of *Napaeozapus?* I have found no published records, and can contribute a single note only on this mouse.

On November 14, 1932, while examining the stomach of a skunk taken two days previously, I found the remains of two *Napaeozapus*. The hind quarters, part of the tail and considerable fur of the two mice were present.

Can we argue from this that the two mice, hibernating together in shallow quarters, were dug out in a lethargic condition and eaten by the skunk? Of over 1200 skunks examined by the writer, this is the only instance met with where the animal had dined on a jumping mouse.

Why the animals hibernate we do not dare hazard a guess. Mouse food is not too scarce during the winter, and the mice practice a limited storage.

It seems necessary for the mouse to lay on a certain amount of fat before it is capable of hibernation. This likewise seems true with the woodchuck. All our late records are of animals, usually immature, that did not exhibit a layer of fat when skinned, for November 13 and 18 specimens of *Zapus* were without a trace of fat. The heaviest *Napaeozapus* (those with most fat) were first to hibernate among our captives. The fat on a late fall specimen is well distributed over the back, all over the viscera, but most abundant and deepest on and about the inguinal region.

I had hoped to make extensive observations on the hibernating *Napaeozapus,* having eleven live individuals in the late fall of 1932. All but three died in hibernation, however, and the data are scanty on this important phase of their life. As previously mentioned, the enclosures were outdoors, with the vicisitudes of the varying but rigorous northern winter acting on and about their home. The large nest box (bushel capacity) was partly filled with dirt and on top of this was placed a thick carpet of leaves. A metal strip to keep out excessive moisture was placed over this, which in turn was covered with leaves and several shocks of cornstalks. The mice gathered into little groups of five and six, possibly for the added warmth thus afforded. In the open enclosure, sometimes partly covered with snow, were kept several large sunflower heads, so that the mice, if awakening from their sleep, might have access to a meal at any time.

The loss in weight of the three mice that survived the winter are recorded below:

A, an adult male, weighed 24 grams on November 24, 1932, an increase of 6 grams from the time of its capture in mid-June. On November 27, 1932, after it had been in deep sleep for three days, and felt cold to the touch, the animal weighed 22.3 grams. A week later it had lost another gram, and until its time of awakening in late April, it lost weight very gradually, its weight at emergence being 16.7 grams. A loss of 7.3 grams, equal to about 30 per cent of the original weight, occurred while the animal was asleep.

B, an adult male, weighed 27.5 grams on November 24, 1932. Four days later, after sleeping during the intervening period, it weighed 25.9 grams. A week later it had lost another .8 gram, and throughout the winter, weighed at two-week intervals, it lost weight regularly. Upon emergence it weighed 17.8 grams, or a loss of 9.7 grams (35 per cent).

C, an adult male, on December 2, 1932 weighed 24 grams. Five days later, after sleeping in the interim, the mouse had lost 2 grams. Two weeks hence another gram had been lost. Upon emergence the animal weighed but 16 grams, a loss of 8 grams (33 per cent).

Four others that commenced hibernation showed an immediate loss, gradually becoming less marked. Two did not show this irregular loss in weight, but commenced to lose more slowly and regularly. Two animals did not hibernate at all, and subsequently escaped in late January or early February.

From the foregoing data, we may tentatively suggest that this group of hibernating mice tends to show a marked loss immediately after hibernating has commenced, and that this rapid loss is lessened perceptibly as the sleep becomes more pronounced. Woodchucks do not show such a marked loss, the greatest drop being after they have emerged from hibernation in the spring. But *Marmota* usually emerges from hibernation a month before food is abundant, and must rely on its reservoir of stored fat to carry it through this month of fasting. Jumping mice apparently do not awaken until food is abundant, so that they begin at once to make up the loss they have experienced in their long winter sleep.

The animals that died during hibernation all had shrunken tails and feet, while the stomachs contained varying amounts of food. Can it be that the emptying of the alimentary canal is necessary for hibernation?

Three days after a mouse assumed the winter torpor, a toe on the fore foot was incised, and although the animal was asleep, and cold to the touch, the wound bled freely. An animal so treated after being dormant for a period of two months showed no bleeding whatsoever. The respiration at this time was so low, that continued observation for a quarter hour showed no indication of abdominal movement.

A characteristic posture is assumed by the hibernating *Napaeozapus*. The animal rolls itself into a ball, the nose thrust down behind the hind legs near the vent, and the long hind legs drawn up alongside the face, usually obscuring the eyes. The tail is coiled up much like a watchspring, and the mouse either rests upon it, or the tail is carried to one side of the body. The forelegs are of course hidden from view, laid against the chest. There is little variation from this position.

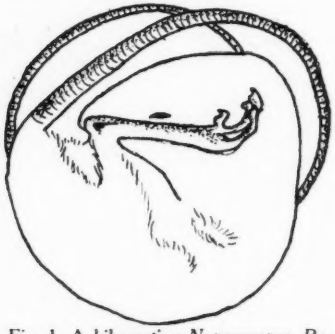


Fig. 1. A hibernating *Napaeozapus*. Redrawn from a photograph. Natural size.

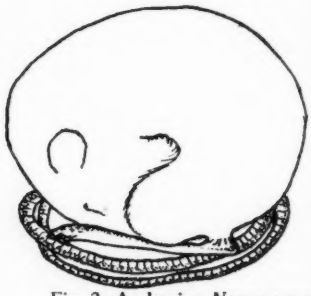


Fig. 2. A sleeping *Napaeozapus* Natural size.

Emergence from Hibernation

Zapus.—On April 27, 1927, I collected a single adult male on the flats near the city of Ithaca, New York. F. P. Metcalf collected a specimen on April 28, 1915, at Ithaca, New York. One was seen April 27, 1932, at East Ithaca, New York. Two were seen by a group of twelve students on May 3, 1928. On May 4, 1932, three were seen in a rank growth of skunk cabbage on the Renwick Flats at Ithaca, New York. Other reasonably early records are May 5, 1933, May 6, 1927, and May 6, 1924.

It is quite probable that the mice usually make their exit from the winter quarters during the second half of April, and that undoubtedly in southern New York and Long Island they emerge considerably earlier. The above data are not in accord with Davies, Godman and Thompson, who tell us that *Zapus* does not emerge from hibernation until the last of May or early June.

Napaeozapus.—Sometimes negative results are as enlightening as those of a positive nature. On April 1, 1933, I set 125 traps in exceptionally good *Napaeozapus* habitat. In the same area the previous June I had taken over 50 specimens in three weeks trapping, in this same locality, and subsequent trapping in June of 1933 showed the mice to be more abundant than the previous year. April 1 was warm, the temperature rising to 65° Fahrenheit. On April 3 the number of traps was increased to 225, and attended daily until they were removed on April 7. Not a single *Napaeozapus* was secured, while over 100 *Blarina* and a score of other small mammals were secured. From this we may argue that the jumping mice were not abroad at this early season.

Ithaca records for May 3 and May 6 are the earliest; yet it is very probable that the mice emerge from hibernation before these dates.

Reproduction

Zapus hudsonius

Merriam, (1886, p. 292) quoting a Mr. Slade, writes: "As a rule, three litters are produced in a season, each consisting of two to four young." Brimley (1923, p. 263) writing from North Carolina, says: "One lot of seven embryos September 17, 1891 and one lot of eight young taken with an adult female June 13, 1895." Probably Kennicott (1856, p. 96) comes nearer the truth when he says: "It produces only two to four young at birth, and being a hibernator, probably not over one or two litters a year."

It would seem from my observations in New York, that but one litter is raised annually. We know such is not the case in the South, from Brimley's record from North Carolina quoted above. Probably *Zapus* does not hibernate in that latitude, or if it does, the sleep is much interrupted.

Zapus Breeding Records
(Central New York)

May 24, 1931	♀	ad.	Four 1 mm. embryos
June 1, 1932	♀	ad.	Two 2 mm. embryos
June 2, 1932	♀	ad.	Four 16 mm. embryos

June 2, 1932	♀	ad.	Four 4 mm. embryos
June 6, 1932	♀	ad.	Recent parturition, 4 scars
June 14, 1933	♀	ad.	Nursing, 4 placental scars
June 25, 1931			Two young, about 10 days in nest.
July 6, 1929			Five young in nest with adult female. Young about weaned.

From this scanty data we may gather that the young, two to five in number, are born in early June. The two young taken on June 25 were in a nest composed of leaves and a few grasses, under a rotten log in an exposed, closely cropped cow pasture. A large stream was fifteen yards distant. The mother escaped. The young, with unopened eyes, had the characteristic color of the adult but were paler. Both were males and each weighed 4 grams. Their average measurements were: total length, 87 mm.; tail, 35; hind foot, 16. The July 6 nest was in a tussock of grass above the ground level, in a rather dense blueberry swamp.

Napaeozapus Breeding Records

(Central New York)

The most detailed account of the breeding behavior of any American zapodid is given by Snyder (1924, p. 234) who records a *Napaeozapus* carrying nesting material to a hole, the entrance of which was covered during the day. Five young, supposedly a week old, were found to be naked and sightless, the white tip of the tail being apparent at this early age. The nest was 6 inches from the surface, and 14 inches from the single entrance. Snyder's account deals with the mouse in Ontario. The following records are principally from Ithaca, New York, and environs:

June 3, 1924	♀	ad.	Recent parturition, 4 placental scars
June 12, 1932	♀	ad.	Four 13 mm. embryos
June 12, 1932	♀	ad.	Four 2 mm. embryos
June 12, 1932	♀	ad.	Five 13 mm. embryos
June 12, 1933	♀	ad.	Four 6 mm. embryos
June 14, 1928	♀	ad.	Five 1 mm. embryos
June 14, 1928	♀	ad.	No embryos
June 14, 1932	♀	ad.	Four 7 mm. embryos
June 16, 1932	♀	subad.	No embryos
June 18, 1932	♀	ad.	Four 17 mm. embryos
June 23, 1932	♀	ad.	Four 20 mm. embryos
June 26, 1932	♀	ad.	Nursing, 4 placental scars
June 28, 1932	♀	ad.	Nursing, 4 placental scars
June 28, 1932	♀	ad.	Nursing, 5 placental scars
June 29, 1932	♀	ad.	Nursing, 5 placental scars
June 29, 1932	♀	ad.	No young to date
June 30, 1932	♀	ad.	Four 17 mm. embryos
June 30, 1932	♀	ad.	Recent parturition, 4 scars
June 30, 1932	♀	ad.	No young to date
July 7, 1932	♀	ad.	Four 18 mm. embryos

From June 12-26, 1933 twenty-two adult females were collected and caged. Young were born to a number of these, but *all were eaten* within a few hours

after birth, although the adult animals were supplied with an abundance of food such as they feed upon in the wild state.

A litter of four young *Napaeozapus* born on June 24, 1932 average exactly one gram each at birth, as did those of a litter of five young born on June 17, 1933. The new born young average, in millimeters, as follows: total length, 42; tail, 12; hind foot, 5. At birth, the tail is very pointed, and shows the characteristic rings of the adult, although the tail tip is not noticeably lighter than the remainder of the animal. The young are blind and naked, like the young of true mice, but they differ in having no vibrissae, as Svihla (1933, p. 132) has recently pointed out for *Zapus trinotatus*.

A wild-caught female, two weeks after capture, died during parturition. The head of the first young had been presented, but the effort proved too much for the mother, and she was cold and stiff when found. Three others were found in the uterus upon dissection.

A one-third grown *Napaeozapus*, weighing 8 grams, was captured on August 5, 1933 near Ithaca, New York, by E. C. Rainey after a spirited chase. A male not over two months old was taken by the writer on August 10, 1933 a few miles east of Ithaca, New York. It weighed 9.3 grams.

Usually a single litter is produced, sometimes between early June and mid-July.

Food

Zapus.—Bailey (1923, p. 120) says of these mice: "They feed largely on seeds of grasses, cutting and drawing down the stems until the heads are reached."

Seeds undoubtedly comprise their favorite food. In the little mouse world of the meadows, even a casual observer may, with little exertion, find the criss-cross piles of slender grass stems, that have been cut by the jumpers in reaching for the seed heads. These sections, the length of a match, may be in little bundles, and are not to be mistaken for the shorter sections left by *Microtus*.

Grass seeds, however, are not the sole food of these mice. Berries, nuts, fruits of various kinds and roots are eagerly sought, and even insects are not disdained. Schmidt (1931, p. 116) remarks: "Two specimens . . . had eaten several yellow geometrid caterpillars that feed on sweet fern."

An adult male collected in a swamp at Freeville, New York, had been feeding extensively on blueberries. An individual collected at Mays Landing, New Jersey, on May 15, 1931 had what appeared to be black muck in the stomach, with a few minute black undetermined seeds. Four June 1932 specimens from Ithaca, New York, had finely comminuted vegetable matter and traces of insect remains. A specimen collected in early November in a cattail swamp had the stomach filled with a starchy paste, perhaps the rootstocks of *Typha*.

In captivity the animals freely ate currants, blackberries, raspberries, the

seeds of tomato, melon and sunflower seeds, and small cutworms. One consumed a slug.

Napaeozapus.—In a little Canadian Zone pocket near Ithaca, New York, on June 16, 1932 I found that some small animals had been cutting down the stalks of mitrewort *(Mitella diphylla)* and feeding on the seeds. Traps set at several of these little "stations" soon caught a woodland jumping mouse, and subsequent analysis showed this animal, at least, to be one of the species responsible for the fallen stalks. A month later the freshly chewed green fruit of the May-apple, *(Podophyllum peltatum)* was found in little bunches. Suspecting this to be the work of a chipmunk, I set several traps at each pile, and was rewarded with the capture of two jumping mice. I cannot be at all sure if these animals were responsible for the presence of the fruit in such piles, but the evidence is strongly circumstantial.

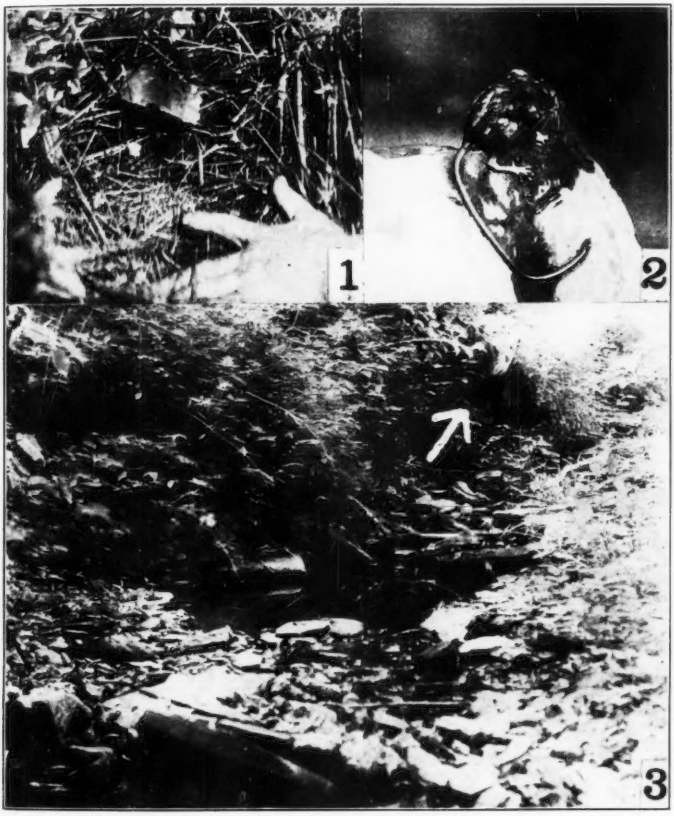
Stomach analyses, however, are positive, and leave no room for doubt as to certain foods eaten. The stomachs of three jumping mice opened on June 11, 1932 contained several hundred tiny black seeds, a number of partly digested small caterpillars, apparently geometrids, and some chitinous parts of an adult insect, probably a beetle. On June 13, 1933 three freshly-killed mice were examined for stomach contents. One had six small insect larvae, three being lepidopterous and three dipterous, with much green matter and some starchy remnants of seeds or rootstock. The second had ten or more small larvae and much green matrix. The third contained all black matter; included in this were thirty or more larval remains, two larger grubs and the fragmentary parts of an adult crane-fly. The following day two males were collected, and contained small enchytrid worms, several small caterpillars and much green vegetable matter. A female taken June 16, 1933 had many small insect larvae embedded in a mass of green vegetable matter.

In several individuals the stomach contents were weighed. One had eaten 2 grams of food, another 2.4 grams, another 3.1 grams, and one had consumed 4 grams. This last would be equal to 25 per cent of an average adult June individual. If the amount of food eaten by captive animals is any indication of the amount consumed daily in the wild state, jumping mice normally eat daily a quantity equal to half their weight.

Saunders (1921, p. 237) speaking of the habitat in which several were caught, says:

> Further search revealed a little pile of the scales of alder fruit, and a trap set at that place by Mr. Thompson caught a mouse the next night, and near it was an alder cone partly eaten. Wether the animal is partly aboreal—totally unexpected, if true—could only be guessed at.

PLATE 6



FIGURES

1. Feeding table of *Zapus*. These feeding areas are characterized by two- or three-inch sections of the stalks of grasses, which have been cut down as the mouse reaches for the seeds.

2. A woodland jumping mouse, *Napaeozapus*, drying itself on a boulder in a stream bed. The white-tipped tail distinguishes this genus from *Zapus*. Note the long hind feet, an adaptation for leaping.

3. Habitat of *Napaeozapus*. The arrow points to a stump under which seven of these mice were taken in twelve nights.

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NOTES ON THE NORTHERN TUFT-EARED SQUIRREL, SCIURUS ABERTI FERREUS TRUE, IN COLORADO

OTIS WADE

Several summers in Colorado, spent in a territory roughly from the Rocky Mountain National Park south to Denver, afforded opportunities for observation of this very handsome squirrel.

Several things of interest have been noted. It is not abundant in any locality where the writer has been. The only place it could be said to be fairly common is at Evergreen and at Bergen Park — both localities are in the Denver Mountain Parks System and have many summer residents. It may be the resulting plentiful food supply (table scraps) has been a factor in its increased numbers and prevalence. It can be seen especially around inhabited cottages and camp sites eager to get its share of fruit, green vegetables, toast and other "tidbits." Another factor, I believe, playing a part in the increase of this squirrel, especially in these "open," more accessible localities, is the protection the state of Colorado has given it the past five or six years.

Coming down the South St. Vrain in August 1932, two individuals, a young one and an old one, were seen near the road. They were not together but probably a half mile apart. These are the only ones seen by the writer in those parts although that region has been visited at various times since 1924. Mr. W. L. Burnett, Curator of the Museum and Mammalogist at the Colorado Agricultural College, informed me that the Abert squirrel is scarce in the region just mentioned and indicated that I was fortunate to see them near the highway. Dr. R. J. Pool of the Botany Department of the University of Nebraska, tells me that several tuft-eared squirrels were daily visitors to the "banquet table" he fixed up near his cabin in Estes Park last summer and that they were quite pugnacious and ready to "fight for their rights."

The past summer (1933) the writer had an excellent chance to study these squirrels in the Denver Mountain Park regions daily for two months, especially at Evergreen where a number were in evidence every day at different times — always in the morning and early forenoons. In the trees around our cabin we had four regular visitors, two large mature individuals and two young ones, probably yearlings. They seemed to be "individualists" — that is, each went its own way, looking for food, entertaining itself and resting and sleeping alone on some limb. The younger ones were very playful and the various antics of one in particular on several occasions almost constituted a "show." This one would run up and down the bole of a tree, hang suspended by the hind claws, then rush around the tree trunk several times "like a streak," down onto the ground, roll over, turn somersaults and make amazing stiff-legged jumps into the air.

Melanism seems to be a common characteristic of this subspecies in central Colorado. Anthony in his Field Book of North American Mammals, page 256, states that it is "said to occur in a uniform dark brown phase." Not only is this true but the writer has closely observed several which were totally black. More often, however, the tip of the tail, the top of the head and perhaps some of the back, show dark brownish with the rest of the body uniformly black. Several very dark ones were seen with grizzled or grayish-tipped tails. Of the four, already referred to, seen commonly about the cabin, two were black, one old one and one young one; the latter was totally black (a fairly good snapshot of it was secured which demonstrates this fact), while the old one showed the tail with a brown tip. One of the characters given for this variety in Anthony's Field book is "gray upper parts without the reddish dorsal band." And yet, both of the typical gray individuals already alluded to showed this dorsal longitudinal marking as a reddish-brown band plainly — it was quite distinct in the older one. Farther down over the side of the hill near Evergreen Lake another large gray individual was seen freqeuntly and this one also showed a decided reddish-brown dorsal band, broad and extending from the crown of the head to the base of the tail. There seems to be a common notion among the residents, both summer and permanent, of this section (probably general throughout the range of the squirrel) that this melanistic color variation is a sexual one — a notion no doubt originating with the natives and passed on to the visiting residents. No one seemed to know whether the black phase was the male or the female.

Where the Abert form was common the Pine squirrel (*Sciurus fremonti fremonti* Audubon) was not to be seen — this fact finally dawned on the writer after the first few days of eager watching of the tuft-eared form, which at last could be seen every day and almost at will. Then a lookout for the Pine squirrel began and one day one was finally heard and then sighted up a small creek called the "Little Cub" about four miles southeast from Evergreen environs. Later on others were seen back in the timber, more or less virgin territory not a part of the summer colony.

The same state of affairs seemed to be true of the Bergen Park region where the tuft-eared squirrel was frequently seen, some large black ones, but no Pine squirrels until one got back into sections where no Abert squirrels were observed and where the forest was less open — this was noticeable along the Squaw Pass road. On several occasions red squirrels were seen along a small stream just off this road some five miles beyond Bergen Park. It is probable that the larger species, being equally pugnacious, drives the smaller Pine squirrel out and that they do not live in harmony. Otherwise the latter species, from what is commonly known about it, would be quite ready to enjoy the "advantages of civilization" and partake of the viands discarded by man.

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THE BRACHIOPOD PUNCTOSPIRIFER PULCHRA (MEEK)

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The brachiopod *Spiriferina pulchra* (Meek), 1860,[1] is one of the most abundant and characteristic fossils in the upper part of the Phosphoria formation of western Wyoming. For this reason, the fauna in which it occurs has sometimes been referred to as the "*Spiriferina pulchra* fauna." The species is found associated with other brachiopods whose age has been interpreted as Middle Permian by R. E. King.[2] During 1933 A. K. Miller collected ammonoids in western Wyoming from a horizon below the Rex chert member, which forms the top of the Phosphoria. The age of these cephalopods, he says, is almost certainly Middle Permian.[3] *Spiriferina pulchra*, then, is apparently of Middle Permian age, and is known to occur in Wyoming, Utah, Idaho, Montana, California, and in Nevada, where the type specimens were collected.

F. J. North[4] has pointed out that in Great Britain, brachiopods which have been referred to *Spiriferina* d'Orbigny, 1847, range from the Carboniferous into the Lias; and even though the internal structures of the early ones are not well known, the shells are divisible into two groups which exhibit "certain persistent differences in external appearance involving both contour and ornamentation." On this basis he divided the genus into two genera, restricting the name *Spiriferina* to one group and applying the generic name *Punctospirifer* to the second group. The characters of the two genera are summarized as follows:

The genus *Spiriferina* d'Orbigny s.s. consists of spiriferid brachiopods characterized by (1) a coarsely punctate shell structure, (2) a well developed median septum in the ventral valve, (3) a hinge line no longer than the width of the shell, (4) rounded cardinal extremities, (5) a moderately low curved cardinal area, (6) a few sharp lateral plications decreasing in amplitude from and including the median fold, (7) an angular fold and sinus which resemble the lateral plications and sulci, from which they differ only in size, (8) rounded margins on the cardinal area which curve over into the lateral slopes, and (9) a simple transverse jugum internally.

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1 For synonymy up to 1930 see Branson, C. C. Paleontology and Stratigraphy of the Phosphoria Formation. Univ. of Missouri Studies **5**(2):36-37. 1930.

2 King, R. E. The Geology of the Glass Mountains. Univ. Texas Bull. **3042**:30-33. 1930.

3 Personal communication.

4 North, F. J. Quart. Jour. Geol. Soc. London **76**:162-223. 1920.

The genus *Punctospirifer* North consists of spiriferid brachiopods characterized by (1) a coarsely punctate shell, (2) a well developed ventral septum, (3) slightly rounded or sub-angular cardinal extremities, (4) a moderately high flat or concave cardinal area, (5) six to ten rounded plications on each lateral slope, separated from each other by rounded sulci which are about equal to the plications in width, (6) a rounded fold distinctly raised above the general level of the brachial valve, (7) a wide, shallow sinus on the pedicle valve, (8) angular margins on the cardinal area which set it off sharply from the lateral slopes, and (9) presumably a V-shaped jugum.

A study of a number of specimens of *"Spiriferina" pulchra* from the upper part of the Phosphoria formation of Wyoming indicates that this species should be referred to the genus *Punctospirifer*. The genus has been analyzed by Dunbar and Condra and they have placed the well-known *"Spiriferina" kentuckyensis* in *Punctospirifer*.[5] A comparison of the external features of *Punctospirifer pulchra* with the external features pointed out by North as characterizing the genus *Punctospirifer*, is as follows:

1. *Punctospirifer* is about twice as wide as long. My specimens of *P. pulchra* show considerable variation in the ratio of width to length. The most typical specimens have a ratio of width to length as 4 is to 3, some have a ratio of width to length as 2 is to 1, but never does the length equal or exceed the width, although some specimens show them to be nearly equal.

2. The cardinal extremities are rounded or sub-angular in *Punctospirifer*. My specimens have cardinal extremities which are rounded, sub-angular or, more rarely, alate.

3. In *Punctospirifer* the greatest width is at or near the hinge line. My specimens generally have the greatest width at the hinge line.

4. The cardinal area of *Punctospirifer* is moderately high and is markedly concave toward the beak in the genoholotype *(P. scabricosta* North, 1920). The Phosphoria specimens possess a moderately low cardinal area which is relatively flat, becoming concave toward the beak.

5. *Punctospirifer* has angular margins on the cardinal area which set it off sharply from the lateral slopes. In my specimens the lateral slopes are set off from the cardinal area by a distinct angle in the shell.

6. *Punctospirifer* has a wide shallow sinus, on the genoholotype three times as wide as deep. My specimens show a wide, almost flat-bottomed sinus, about three times as wide as deep.

7. In *Punctospirifer* the lateral slopes of both valves are ornamented with rounded plications separated by rounded sulci. There are seven to ten plications on each side of the fold and sinus. The Phosphoria specimens show a

5 Dunbar, C. O. and G. E. Condra, Brachiopoda of the Pennsylvania System in Nebraska, Nebraska Geol. Surv. Bull. **5**:350. 1932.

similar decoration. The seven to ten (rarely more) plications on each lateral slope are separated by rounded sulci on some specimens and by fairly sharp ones on others.

8. *Punctospirifer* has a broadly rounded fold which is raised above the general level of the shell and which is much flatter and broader than the lateral plications. *P. pulchra* has precisely this sort of a fold.

9. North points out that in *Punctospirifer* the " . . . surfaces of both valves are crossed by regularly-disposed imbricating lamellae, which in adult specimens may be more or less obsolescent, especially on the posterior portions of the valves."[6] Many specimens of *P. pulchra* have shells which are entirely lamellose, but on most specimens the lamellae on the posterior portion were either not well developed or not well preserved. The anterior margins are generally strikingly lamellose, so much so, in fact, that they are much thickened by the numerous lamellae.

10. Along the hinge line, the width of the genoholotype of *Punctospirifer* is 20 mm., the length of the brachial valve is 12 mm., and the height of the cardinal area is 10 mm. The Phosphoria specimens considerably exceed these dimensions, except for the height of the cardinal area. A typical specimen shows a width of 40 mm., and a length of 27 mm. An alate specimen is 50 mm. wide and 18 mm. long. The height of the cardinal area rarely exceeds 4 mm. North points out that the British Carboniferous punctate spiriferids are smaller than the Liassic ones, and that the Permian ones are smaller than either. He attributes the small size of the Permian ones to an unfavorable environment, and the large size of the Liassic ones to the fact that the race was nearing extinction.

11. The shell structure of both *Punctospirifer* and *Spiriferina* is coarsely punctate. In *P. pulchra* about six irregularly distributed punctae occur in the space of a square mm. The shell substance of the cardinal area is as coarsely punctate as the surface of the valves.

The internal features which characterize the genus *Punctospirifer* and those present in *P. pulchra* are not as well known as the external ones, and a comparison is less easily made. In *Punctospirifer* the dental plates are slightly divergent, and in the genoholotype are attached to the floor of the valve for about a third of its length. In my specimens of *P. pulchra* the dental plates are slightly divergent from the hinge line toward the beak, and somewhat divergent from the beak toward the anterior margin. In a specimen 20 mm. long the dental plates are fused to the floor of the valve for about 6 mm., and diverge at the same rate as the margins of the sinus. In the genus *Punctospirifer* the ventral septum is well developed and is two-thirds of the height

6 Girty, in his discussion of the Guadeloupian fauna, has pointed out that the genus *Spiriferina* may be divided into groups on the basis of the nature of the lamellae. North, however, in erecting the genus *Punctospirifer*, has considered this character to be of less importance than shell-contour.

of the valve at a point near the beak. In the genoholotype the septum is attached to the floor of the valve for about half the length of the valve. The Phosphoria specimens show a ventral septum which bisects the sinus and extends from the beak anteriorly for about half the length of the valve. In a specimen 20 mm. long the septum is fused to the floor of the valve for 10 mm. No mention has been made by North of the shape of the jugum in the genoholotype of *Punctospirifer*, and this structure is not discernible in my specimens.

In general, then, the features of *Punctospirifer pulchra* show a close agreement with the features North considers to be characteristic of this genus. The most marked disagreement, perhaps, is noted in the height of the cardinal area of *P. pulchra* as compared to that of *P. scabricosta*, the genoholotype.

Considerable variation is found in specimens of *Punctospirifer pulchra*, the most apparent being variations in the ratio of length to width, variations in thickness, variations in size, and variations in the height and concavity of the cardinal area. With critical study, several varieties might be distinguished.

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PLATE 7

FIGURES

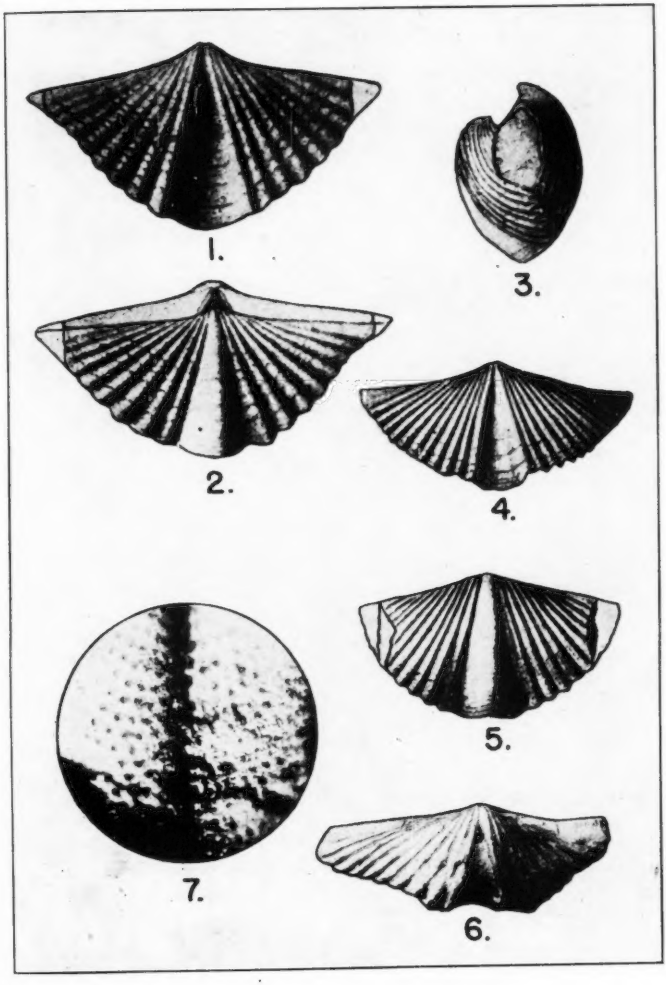
1–2. Ventral and dorsal views of the type specimen of *Punctospirifer pulchra* (Meek). These figures are slightly larger than Meek's illustrations. After Meek, U. S. Geol. Expl. 40th Par., Final Rept. 4(1): pl. 8, figs. 1 and 1a, 1877.

3–5. Side, ventral and dorsal views of specimens illustrated by Meek which more closly approach the size of typical Phosporia specimens of *P. pulchra*. After Meek, U. S. Geol. Expl. 40th Par., Final Rept. 4(1): pl. 12. figs. 12, 12d and 12c.

6. An alate specimen of *P. pulchra* from the Phosphoria formation of the Wind River Mountains, Wyoming. The cardinal extremities are broken.

7. Enlargement of parts of two lateral plications and an intervening sulcus of a silicified specimen of *P. pulchra* from the Phosphoria showing the punctate character of the shell. x 15.

PLATE 7



A NEW MIOCENE LOCALITY IN NEW JERSEY

HORACE G. RICHARDS

The Miocene of New Jersey is represented by the Kirkwood and Cohansey Formations. The Shiloh Marl forms the upper bed of the Kirkwood and is highly fossiliferous. On the basis of the fossils the Kirkwood is believed to correspond in a general way with the Calvert Formation of Maryland, the lowest division of the Chesapeake Group.

Except for "obscure casts of molluscan shells of no value in determining its age" and a few plant fossils the Cohansey sand is non-fossiliferous. (Lewis and Kümmel, 1915, p. 73). In as much as sands and clays similar to the Cohansey are revealed in borings along the coast and as these overlie clays carrying fossils characteristic of the St. Mary's, the highest division of the Chesapeake Group, it is probable that the Cohansey belongs to a still later phase of the Miocene or possibly the Pliocene.

Fig. 1. *Crassatella melina* Conrad in sandstone slab from Miocene at Fairton, New Jersey. (natural size).

Well borings at a number of places along the coast have demonstrated a great thickness of the Miocene of New Jersey. At Atlantic City the Miocene is present between –390 feet and –1225 feet and the fossils are referable to the St. Mary's, Choptank and Calvert Formations of Maryland.

By far the greater number of fossils from the Kirkwood Formation of New Jersey comes from Shiloh in Cumberland County. The marl pits on the Shepard farm near this town afford excellent material today. (See Pilsbry

and Harbison, 1933.) Other material has been collected from marl pits at Jericho, nearby. Mr. William Tullner recently rediscovered this locality at "Elwells Pits" near the town of Jericho. Although the pits were filled, a few specimens of *Perna maxillata* Conrad and *Venus* sp. were obtained on a visit to the pits on September 11, 1933.

The locality described in this paper is at Fairton, Cumberland County, New Jersey, and was pointed out by Dr. Frederick Oldach, of the University of Pennsylvania. On the farm of Mr. Joseph C. Shoemaker, just south of the main highway at the bridge over Cohansey Creek, some large slabs of consolidated sandstones had been dredged from the bottom and right bank of Mill Creek, a branch of the Cohansey. In many of these slabs are the fairly well marked impressions of mollusks. Although indurated boulders have been found in the Bridgeton Formation (Pleistocene), probably having been reworked from the Kirkwood, (Salisbury and Knapp, 1917, p. 31) as far as is known this is the only example of consolidated fossiliferous sandstone from the Miocene of New Jersey. The cementing material appears to be silica.

The locality is mapped as being in the Kirkwood Formation. Although the fossils are few and are difficult to determine, they appear to be the same species as those found in the marl pits at Shiloh, and therefore favor a Kirkwood dating. The dominant species is *Crassatella melina* Conrad. In addition the following have been determined: *Nucula proxima* Say, *Ostrea virginica* Gmelin, *Astarte* sp., *Turritella cumberlandia* Conrad, *Discina lugubris* (Conrad) and *Belanus withersi* Pilsbry.

The slab in the photograph and several other specimens have been deposited in the New Jersey State Museum at Trenton, N. J.

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NEW JERSEY STATE MUSEUM,
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A NEW SPECIES OF SPIRULINA

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For a number of years a *Spirulina* has been collected by Dr. J. H. Hoskins of the University of Cincinnati, from a lake on the campus of the University of Notre Dame, Notre Dame, Indiana, which warrants the position of a new species.

Spirulina densa sp. nov.

Trichomatibus pallido-aerugineis, inarticulatis, saepe abbreviatis rectisque aut±elongatis (usque ad 500μ), flexuosis, totis regularissimis, 1.5μ-1.7μ crassis, dense atque regulariter spiralibus, spirae diam. 4μ-4.5μ, anfractibus inter se 2.4μ-2.6μ distantibus.

Hab. in aqua dulci, ad litorem inter varias Oscillatorias fluitans.

Filaments pale blue-green, cross walls lacking, long and flexuous, at times reaching a length of 500μ or more, or short and straight, trichomes very regular throughout, in width 1.5μ to 1.7μ; coils dense, regular, 4μ to 4.5μ wide, distance between coils 2.4μ to 2.6μ.

Habitat: Floating on the surface near the shore of freshwater lake.

Locality: St. Mary's Lake, Campus of the Notre Dame University, Notre Dame, Indiana.

The species of *Spirulina* Turpin are differentiated on the basis of the width of the filament, the width of the coils, the distance between coils, and the regularity of the coils.

Spirulina densa falls within the section *Euspirulina* of Geitler.[1] Its position lies intermediate between *S. major* Kütz. and *S. subsalsa* Oerst., the main point of distinction in either case being the distance between coils and the ratio of this distance to the width of the coils. *Spirulina major* is described by Geitler as being pale to bright blue-green in color, filaments 1μ to 2μ wide, coils usually regular, 2.5μ to 4μ wide, and 2.7μ to 5μ distant from each other. An examination of all the material of *Spirulina major* available for study from the U. S. has revealed that the species falls very definitely within the limits of this description. It has been observed that within the species, in general when the width of the coils is great, the distance between the coils is great; when the width of the coils is small, the distance between them is correspondingly small. In effect, the distance between coils varies directly as the width. However in *S. densa* the width of the coils is relatively great; the distance between coils is slightly less than that found within the limits of *S. major*.

From *Spirulina subsalsa* also the species in question differs primarily as regards the distance between coils. *S. subsalsa* is described by Geitler as follows: trichomes 1μ to 2μ wide, bright blue-green to reddish-violet, seldom regular, usually somewhat irregularly coiled; coils resting or almost resting on

1 Geitler, L.: 1930-1932—Cyanophyceae. In: Dr. L. Rabenhorst's *Kryptogamen-Flora* **14**:916.

Fig. 1. (A) *Spirulina densa* sp. nov. (B) *Spirulina major* Kütz., maximum dimension of coils. (C) *Spirulina major* Kütz., minimum dimension of coils. (D) *Spirulina subsalsa* Oerst.

one another, 3μ to 5μ wide. In *S. densa* the coils are not any closer together than 2.4μ. All the five or six collections from the Notre Dame lake made over a period of as many summers have been remarkably regular in this as well as in all other respects.

On the basis of the distinguishing features here given which are of major importance in the differentiation of species of *Spirulina* as the classification now stands, *Spirulina densa* is proposed as a new species.

The illustrations in the text figure are taken from herbarium material, the larger *S. major* from a collection of N. L. Gardner from Alameda, California, August, 1918, (no. 4356); the smaller *S. major* from a collection made from the Little Miami River, North Bend, Ohio; the *S. subsalsa* from specimen 252 of the Phycotheca Boreali-Americana by Collins, Holden, and Setchell; the *S. densa* from the original material. For the purpose of comparison each is drawn to the same scale, a magnification of 2500 times.

The author wishes to acknowledge the helpful criticism of this work by Dr. J. H. Hoskins of the University of Cincinnati, Dr. H. F. Buell of the University of Minnesota, and Dr. M. A. Howe of the New York Botanical Gardens.

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TOPOGRAPHY AND FOREST TYPES IN A CENTRAL INDIANA REGION

J. E. POTZGER

Next to climate, topography with its influence on edaphic and atmospheric factors probably plays the most important rôle in control of forest types in a given region. So one may expect the greatest diversity in forest types where the surface of the land is diversified and rugged.

This is plainly shown by the belts of forest types in mountainous regions, but in a modified form one will find topographic control operating even in regions of moderate relief.

It is the aim of the present study to show such a topographic control of forest types in Salt Creek township, Monroe county, Indiana.

The study includes such habitats as: dissected uplands, old Pleistocene river terraces, three stages of flood plain development.

Typical places were selected in each habitat and designation was made by capital letters. Station "A" is an old river terrace; "C," "D," "E," "W," "X" various stages of flood plain development, and station "F" an area on the upland (Fig. 1).

Physiographic History

Approximately 5/6 of Indiana was covered by the Wisconsin and Illinoian glaciers. The Illinoian sheet extended two great lobes southward, the large triangle with its apex in the northern part of Monroe county and its sides flanked by Clark and Posey counties was a great driftless area. This driftless area is more or less rugged and dissected. Heavy discharge of waters from the melting ice made glacial sluiceways of thes treams crossing the region, cutting out immense valleys in which these streams are now lost and show this by extensive meandering. One of these streams is Salt creek. Malott (1922) describes these influences upon the topography of the driftless area in Indiana thus: "The passage of glacial waters from the eastern section of the Illinoian ice sheet across the driftless area, and the partial impounding of these waters on the west, resulted in valley trains of gravel, sand, silt and clay which caused local upbuilding of the tributary streams of the driftless area."

The region through which Salt creek passes at the present time is a plateau 750 to 900 feet in altitude, which has been dissected to a depth of 200 to 400 feet. The valleys are steep-sided and rise abruptly to the upland levels. Salt creek flows in a mud-lined channel set below the broad valley floor. Part of the valley floor is occupied by Pleistocene river terraces which rise ten to twenty-five feet above the present flood plain, and in most cases are now eroding rapidly (Fig. 2).

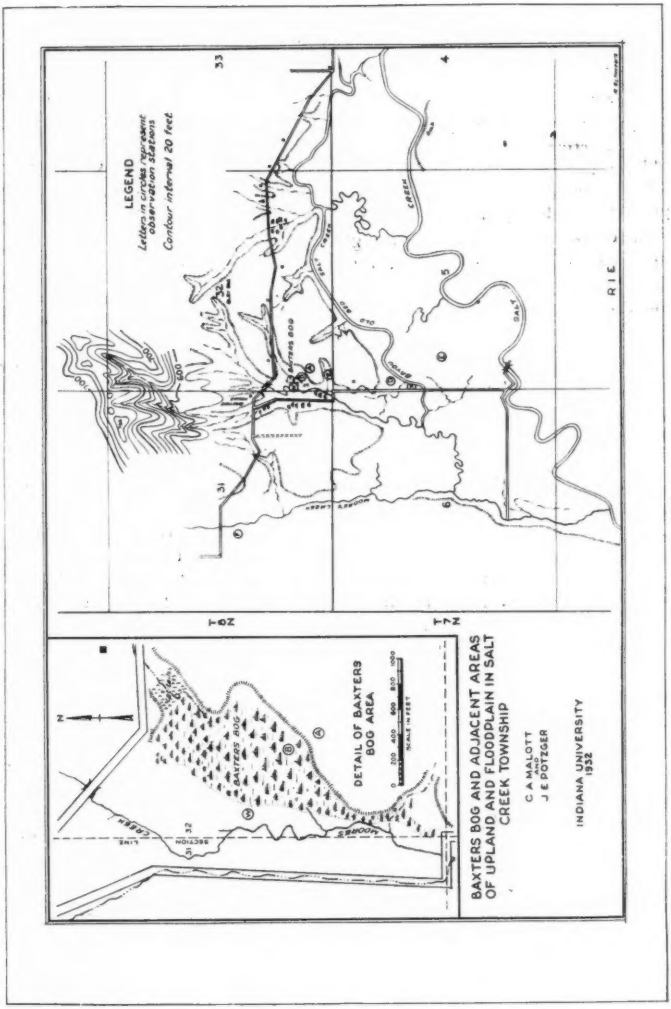

LEGEND
Letters in circles represent observation stations
Contour interval 20 feet
BAXTERS BOG AND ADJACENT AREAS OF UPLAND AND FLOODPLAIN IN SALT CREEK TOWNSHIP
C A MALOTT
AND
J E POTZGER
INDIANA UNIVERSITY
1932
DETAIL OF BAXTERS BOG AREA
T 34 N
T 7 N
R 1 E

Fig. 1

Vegetative History

The region now comprising Indiana was densely forested before the advent of the white man, but when Indiana became settled at the beginning of the last century, there began biotic and cultural influences which have changed the aspect of the original vegetation greatly.

The almost universal climax and sub-climax forest is now predominatingly in stages of primary and secondary succession. Agriculture, fire, grazing, lumbering, erosion, deposition and drainage have combined to reduce this unbroken forest to disjunct patches existing under unnatural conditions imposed upon the habitat by civilization. This is true even of the Salt creek township region where agriculture is not a feature.

About twenty-five years ago the greater part of the lowland forest of the region was lumbered so that the area is now chiefly pasture, fallow fields. farmland, and smaller areas of forest. Early succession of these fallow fields is usually a dense thicket of *Alnus rugosa* (Fig. 3).

The lowland forest (Station "E") was cleared of its large oak and hickory about thirty years ago. The upland forest at station "F" has seen very little disturbance in the last forty years. The slopes are all steep and the soil is quite shallow in most places, especially on the south-facing slopes.

Methods of Study

If ever the word "change" assumes a significant and manifold meaning, it is in the region about Salt creek valley. Old topographic features melt away and new ones arise, while others change their aspect. Streams turn to ponds, old river courses become land, and yet, the present is the sum total of the past. The path of development may be inferred from the traces of the trail still visible or it may be remodeled from the records of the printed page or word of mouth of the early settlers. All of these sources of information were used freely to consummate the present paper.

The whole area was observed on numerous visits to gain a conception of the part which each unit played in the region as a whole. A specimen of each plant species collected was placed in the herbaria of Indiana and Butler universities.

Representative areas of the different types of forest were studied quantitatively by means of chart quadrats and strip transects. In the strip transects, an area ten meters wide but of varying lengths was delimited by stout strings. direction being held by means of a pocket compass. Tabulation and DBH, measurements were made of all woody plants one inch or over in diameter. Woody plants below one inch DBH, but one meter or over in height were counted. When zonation was to be stressed, the strip was subdivided into ten meter quadrats and study continued as described above.

Floristic Aspect of the Region

As an area within the Eastern deciduous forest, Salt creek township has suffered the same devastating influences of civilization as the deciduous forest as a whole. Secondary succession is the most striking feature of the forested

areas as such. The timbered areas have been limited to the less favorable places, i.e., uplands and lowlands, which are either too dry or too wet (at least periodically) for successful farming. Nowhere in the township was typical virgin forest found. The patches of forest termed so, with trees approximately 200 years old, are but the remains of a forest stripped of its more valuable trees. Possibly the groves of pure beech are virgin timber

Fig. 2. Eroding river terrace.

(Table 6), but, again, they may be the result of selective cutting of fifty years ago.

Nowhere in the region was a definite beech-maple climax found, the mesophytic forests are either all beech or mixed hardwoods in which beech and maple might constitute the most prominent members.

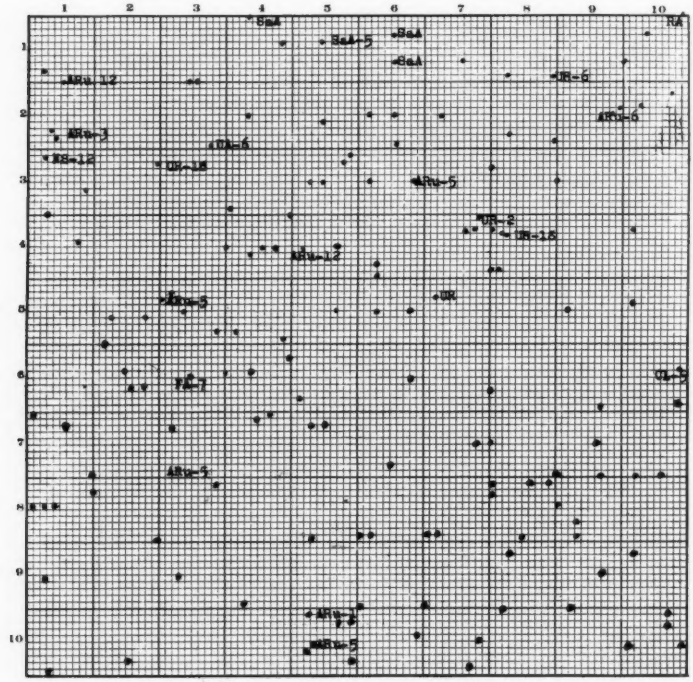
Topographic control of the forest type is very evident. North-facing slopes are mixed hardwoods with beech-maple tendency (Table 1), the same is true for the lower Pleistocene river terraces. The more desiccated south-facing slopes are primarily oak-hickory (Table 3). The flood plain supports di-

versified types of forest, controlled by the degree of deposition with its influence on the height of the water table.

Such areas as station "X" (Table 6), indicate ultimate beech or beech-maple climax on the valley floor. The more wet areas are dominated by a sub-climax forest composed of few species, either the unstable *Acer rubrum* consocies (Figure 4), or the more typical sub-climax forest of *Quercus bicolor*—*Q. palustris* (Figure 5).

Fig. 3

Project, Station "D," Alnus Consocies Survey; Quadrat No. 1, 10 x 10 meters; Oct. 17, 1931; Location, Salt Creek Township, Fallow field.



● = Alnus rugosa—589 stems
ARu = Acer rubrum—9
CL = Carya laciniosa—1
FA = Fraxinus americana—1
NS = Nyssa sylvatica—1
SaA — Salix sp. ?—4
RA = Rubus allegheniensis—1
UA = Ulmus americana—1
UR = Ulmus racemosa—5

Figures, inches in height

Fig. 4. An Acer rubrum consocies at Station "C" adjacent to Baxter's Bog.

Discussion

The Upland Forest

An area represented by station "F" was chosen as typical for the uplands in the region. It was one of the steepest ridges bordering on Salt creek valley, fully 250 feet in height. It also appeared less disturbed by the influences of civilization than most of the other uplands. The trees are widely spaced (Fig. 6), but the crowns form a dense canopy. While the trees are not of the gigantic stem dimensions of virgin forest, many attain a diameter of two feet or more (Table 1).

The striking feature of all these uplands is the dual climax aspect. The north-facing slopes are mixed hardwoods with a strong tendency to beech-maple, while the south-facing slopes are oak or oak-hickory.

Table 2 is a graphic presentation of the vegetational change between north and south-facing slopes. According to some lumbermen, oaks on south-facing slopes are subject to heart-rot. Tillotson and Greeley (1927) attribute this to fire injury while the trees were in the sapling stage.

The south-facing slopes are decidedly more xerophytic even in general aspect, usually one finds abundant rocks exposed, and early succession of foliose and fruticose lichens is common. Station "F" is one of northerly exposure, and as shown by Table 1, to be a mixed hardwoods with beech-maple tendency. In an area of 4,530 square meters (Table 1), *Acer saccharum* has the largest representation with 199 stems one inch or more DBH.; *Fagus grandifolia* with 105 stems in the larger size classes is a close second, however, Fagus with more trees in the ten to thirty inches size classes, controls the crown cover at the present. The oak group is a vital component in the association, and in somewhat lesser degree also hickory. It is possible that *Carya, Liriodendron,* and *Quercus* are represented less because of selective cutting in former years, but the present tendency is certainly towards a beech-maple climax. In the smallest size class, *Acer saccharum* is more abundantly represented than all other dominant species combined.

Carya with 68 stems and the genus *Quercus* with 150 have a creditable representation in the lower size classes, the same may be said of *Nyssa* and *Liriodendron; Fagus,* on the other hand, is not well represented in the below one inch size class. In all such discussions one must not overlook the factor of mortality between the sapling stage and mature trees.

Rübel's (1930) attention was attracted by the abundance of *Acer saccharum* saplings in the hardwoods at Three Oaks, Michigan, yet he found that beech and maple had a fairly equal representation in the older trees. He attributes this to the greater mortality among young maple, saying that beech will quite likely mature if they survive to the second year's growth. In this way mature beech-maple forests become fairly well balanced in representation of the two species.

The upland forests are also marked by absence of lianas, diversified

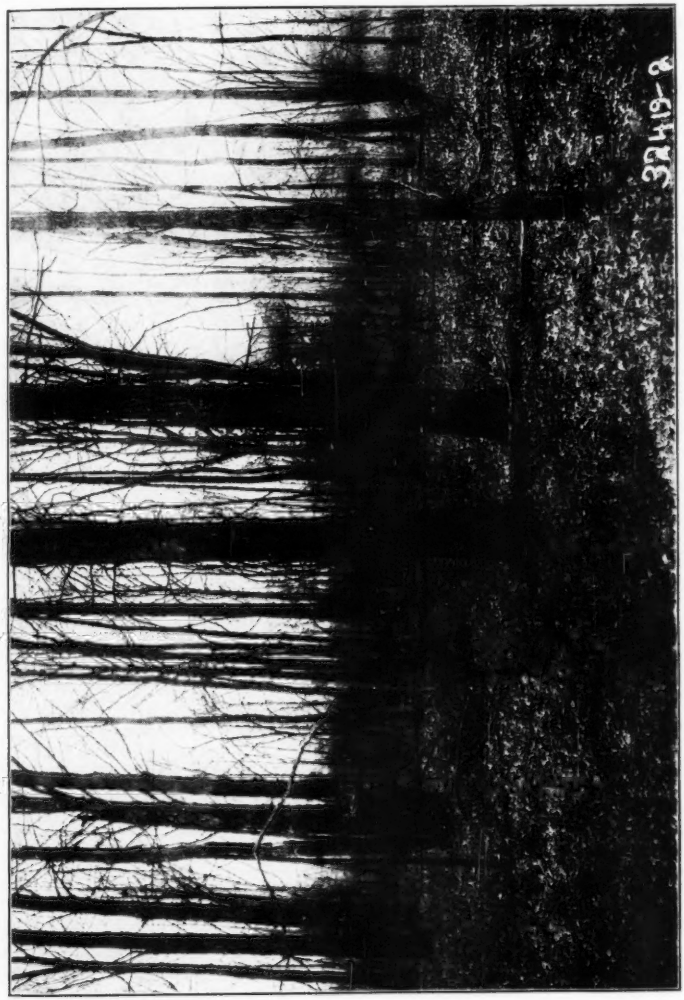


Fig. 5. An older stand of *Quercus palustris-Quercus bicolor* associes. Salt creek valley lowland forest.

layering, and by a sparse ground flora. Among the second layer trees, *Ostrya virginiana* has by far the best representation, and *Viburnum acerifolium* is the most characteristic shrub (Table 1).

TABLE 1

Strip transect in ten meter units, showing density of woody species in four size classes at station "F." (10 x 453 meters) all on north-facing slope.

Species	Below 1 inch DBH 1 meter or over in height	1-10 inches	inches 11-20	21-30 inches	Total above 1 inch	Grand total
Acer rubrum	182	22	–	–	22	204
Acer saccharum	650	196	3	–	199	849
Amelanchier canadensis	8	3	–	–	3	11
Benzoin aestivale	7	–	–	–	–	7
Carpinus caroliniana	5	3	–	–	3	8
Carya cordiformis	2	–	–	–	–	2
C. glabra	22	19	–	–	19	41
C. ovata	44	14	1	–	15	59
Cornus florida	184	32	–	–	32	216
Cercis canadensis	1	–	–	–	–	1
Corylus americana	2	–	–	–	–	2
Fagus grandifolia	54	79	19	7	105	159
Fraxinus americana	53	6	3	–	9	62
Hamamelis virginiana	19	–	–	–	–	19
Hydrangea arborescens	767	–	–	–	–	767
Juglans cinerea	–	1	–	–	–	1
J. nigra	4	2	1	–	3	7
Liriodendron tulipifera	51	4	1	–	5	56
Morus rubra	8	–	–	–	–	8
Nyssa sylvatica	33	1	–	–	1	34
Ostrya virginiana	585	44	–	–	44	629
Parthenocissus quinquefolia	7	–	–	–	–	7
Populus grandidentata	35	5	–	–	5	40
Prunus serotina	10	1	1	–	2	12
Quercus alba	90	16	3	1	20	110
Q. borealis maxima	51	14	8	–	22	73
Q. velutina	9	7	6	–	13	22
Ribes sp.	9	–	–	–	–	9
Rhus copallina	8	4	–	–	–	12
R. glabra	2	2	–	–	2	4
Rubus allegheniensis	338	–	–	–	–	338
Rubus occidentalis	24	–	–	–	–	24
Sassafras variifolium	259	19	–	–	19	278
Smilax rotundifolia	12	–	–	–	–	12
Ulmus fulva	5	2	–	–	2	7
Viburnum acerifolium	424	–	–	–	–	424
Vitis aestivalis	21	–	–	–	–	21

The most outstanding single feature of the upland forest, however, is the dual nature of the forest type. The transition from beech-maple on the north-facing slopes to oak-hickory on the south-facing slopes is not gradual but

Fig. 6. Characteristic forest on north-facing slopes. Upland mixed hardwoods at Station "F."

abrupt and decisive, marked by a sharp line along the ridge (Table 2). The change of dominant species is also reflected by a change of species in the second layer trees as well as by a change in the species of shrubs. However, one ought to mention here that the oak-hickory type of forest is usually quite devoid of shrubs as well as herbaceous ground cover.

Table 2 shows the striking change in forest type as one passes from one slope to the other. In running the transect, the ridge top (approximately ten to twenty meters) was omitted. These ridge tops are either oak or hickory consocies.

Fig. 7. Dense growth of young beech at Station "X."

While maple and beech show the influence of a sharp control factor when the ridge top is reached, maple may at times be found on south-facing slopes, but the trees are usually in the smaller size classes; beech is seldom found in these drier habitats but is, on the other hand, a common early invader of higher places in the lowland forest; of this we shall speak again later.

Strip transect 10×280 meters (in 10-meter quadrats) near station F showing change of forest type between north- and south-facing slopes.
Figures not in the circles DBH in inches of trees one inch or over. Figures in circles, number of stems below one inch DBH., one meter or over in height.

SPECIES	N↑ 1	2	3	4	5	6	7	8	9	10	11	S↓ 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Acer rubrum				(1)				(2)									(1)		(1)									
Acer saccharum	(3)	(5)	(2)	3 (5)	3	10-6-3 3-12-11	6-1-6 (1)	(78)	(44)	4-2-3-1-1 1-2-2 (6)	(54)		8-6-2 (2)	2 (1)	(4)	1 (3)	1-3 (4)		4 (5)	6-5				(2)			(1)	
Asimina triloba								(7)	(2)																			
Benzoin aestivale				(2)		(1)																						
Carpinus caroliniana	3-2-1-1-1-1 3-1-1-2-1-1 3-2-2-3-4 (17)	(50)	3 (5)						(1)																		(3)	
Carya cordiformis			(1)	(1)							(1)																	
C. glabra									10	1	(2)	4 (4)	5-9	9	2-1-2-2 (3)	4-5-6 (2)	7-3-2 (1)	8-8 (1)	3-4-3 (3)		5-4-2	6-3-9 6-4	3-1 (4)	8	(1)	2	1-4	
Celtis occidentalis					10																							
Cercis canadensis		6		(3)		(1)																						
Cornus florida	(6)	3 (3)	3 (1)	2-1-3 3 (4) 3	3-3-2 (5)			2	4	3 (2)	2 (7)				(1)		2 (1)							(4)	(1)	(4)		
Fagus grandifolia	1-3	10-37 (1)	(1)			10	30	30-8	27		25-24																(2)	(1)
Fraxinus americana								(2)	(1)	(1)																		
Hamamelis virginiana					(3)																							
Hydrangea arborescens	∞	∞	∞	∞																								
Juglans cinerea			8																									
J. nigra	14-18	(1)																										
Liriodendron tulipifera			11	15-13 10-16-8 (1)	9																							
Morus rubra																												
Nyssa sylvatica															(2)	(6)												
Ostrya virginiana								7	11-5	2	(15)			(1)			(4)	(2)	(1)									
Quercus alba												10-18 10 (6)	(5)	2-5-1 (1)	2-5 (3)	4-5 9	5-3-6 4-3-5 3 (6)	6-3-5-7 3-11-2	5-11-2 3-9-4 (1)	3-7-6 4-3-5-10 6	3-9-5 4-9-5		10	6-2			6-5-5-3 5-6 (5)	2-9 (2)
Q. borealis maxima													16	4	13 15-10 10 (1)	12-3 12	5-5	8 (2)			5-4-2	6-12-9	14-14	14-6	19-12 (1)	12-15 14	12-14	25-11
Q. velutina					8			6 (2)	10																			
Rhus glabra												(3)																
Smilax rotundifolia																			(2)			(2)	(8)	(4)	(7)	(3)	(1)	
Sassafras variifolium															(1)	(2)									(6)		4-1-5 8-5-1	4-8
Ulmus fulva	4-1-3 (29)	2 (3)	(4)	6	7			(6)		(3)																		
Viburnum acerifolium										(2)	(6)						(2)										(6)	(11)

This topographic control of forest type also affects abundance of species. Table 2 brings out this feature, south-facing slopes have but 50% of the number of species present on north-facing slopes, which is quite striking because only a few hundred feet separate the two habitats.

A compilation of the density of the four most prominent genera of these forest types, i.e. *Acer saccharum, Fagus grandifolia, Quercus, Carya,* in identical area is presented in Table 3. The cardinal points of differences agree with the same differences shown in Table 2. *Acer:* 341% N/S; *Fagus:* 241% N/S; *Quercus:* 341% S/N; *Carya:* 240% S/N; even in per cent an almost identical reversal of type.

The controlling factor in this distribution of forest types is probably an edaphic one, chief of which is evidently soil moisture, influenced by difference in insolation and depth of soil.

Bates (1923) studied the difference in insolation in a small valley in the mountains of Colorado. The total distance from ridge through valley to ridge was about 700 feet; slopes and valleys approximately the same as those in Monroe county. In the maximum temperature of the season he found a difference of 60° F. between the two slopes. The evaporation curve followed the contour of the slopes and valley quite closely, being highest on the south-facing slopes.

Such an interpretation of control factor is also in agreement with the opinion of Warming (1909): "All plant associations are determined primarily by the water content of the soil."

The Flood Plain Forest

Topographic control is not limited to the steeper slopes of the upland alone, where slope and exposure control soil moisture, but is also found to

TABLE 3

Comparing density of *Fagus, Acer, Quercus,* and *Carya* in four size classes on north and south-facing slopes in two 10 x 38 meter transects.

Species	Below 1 inch DBH, a meter or more high		1-10 inches		11-20 inches		21-30 inches		Total above 1 inch		Grand total	
	N	S	N	S	N	S	N	S	N	S	N	S
Fagus grandifolia	15	13	40	4	3	_	_	_	41	22	249	85
Acer saccharum	208	63	38	22	9	_	7	_	56	4	71	17
Quercus alba	5	89	47	132	3	3	_	_	50	135	55	224
Q. borealis maxima	1	12	20	54	5	19	3	1	28	74	29	86
Q. velutina	2	7	4	9	_	4	_	_	4	13	6	20
Carya cordiformis	3	3	18	8	_	_	_	_	18	8	21	11
C. glabra	19	102	39	167	_	_	_	_	39	167	58	269
C. ovata	2	19	10	84	_	_	_	_	10	84	12	103

operate in the lowlands of the flood plain, where not the lack but excess of water becomes a limiting factor for certain species of trees.

The periodically wet lands which are flooded during the wet spring season and where the water table is high for the greater part of the year, support a dense sub-climax forest few in species, dominated either by *Acer rubrum* consocies, (Fig. 4) or *Quercus bicolor-Quercus palustris* associes (Fig. 5). Such forests are common, especially near the stream. As soon as the water table is lowered by filling and the land is dry for the greater part of the season, the forest changes its aspect, being a sort of transition between the sub-climax and the climax mixed hardwoods, with a marked increase in number of species representative of both sub-climax and climax (Table 4).

In Table 4 we have a transect of 10 X 170 meters at station "E" an area typical of such a transition forest.

TABLE 4

Strip transect in ten meter units, showing density of woody species in four size classes at station "E." (10 x 170 meters)

Species	Below 1 inch DBH 1 meter or over in height	1-10 inches	11-20 inches	21-30 inches	Total above 1 inch	Grand total
Acer rubrum	133	19	1	–	20	182
Acer saccharum	22	1	–	–	1	23
Alnus rugosa	10	–	–	–	–	10
Benzoin aestivale	366	6	–	–	6	372
Carya laciniosa	51	18	1	–	19	70
C. ovata	–	1	–	–	1	1
Carpinus caroliniana	217	32	–	–	32	249
Cephalanthus occidentalis	11	–	–	–	–	11
Cornus florida	4	3	–	–	3	7
Corylus americana	3	–	–	–	–	3
Fagus grandifolia	66	8	12	3	23	89
Fraxinus americana	44	5	–	–	5	49
F. lanceolata	4	13	–	–	13	17
Hydrangea arborescens	81	–	–	–	–	81
Liquidambar styraciflua	2	3	1	–	4	6
Liriodendron tulipifera	6	2	2	–	4	20
Morus rubra	2	1	–	–	1	3
Ostrya virginiana	10	2	1	–	3	13
Platanus occidentalis	–	1	–	–	1	1
Quercus bicolor	1	3	1	–	4	5
Q. borealis maxima	4	2	–	–	2	6
Q. palustris	13	4	2	–	6	19
Salix nigra	1	–	–	–	–	1
Sassafras variifolium	2	–	–	–	–	2
Sambucus canadensis	3	–	–	–	–	3
Smilax rotundifolia	3	–	–	–	–	3
Ulmus racemosa	6	20	2	–	22	28
Vitis aestivalis	9	1	–	–	1	10

Such relic species as *Salix nigra, Quercus bicolor, Quercus palustris, Platanus occidentalis, Liquidambar styraciflua, Cephalanthus occidentalis, Alnus rugosa* represent a former wet habitat forest, while the climax mesophytic forest is foreshadowed by such species as *Acer saccharum, Carya ovata, Fagus grandifolia, Ostrya virginiana.*

Fagus occupies a unique position in this tension zone, invading the lowland sub-climax forest as soon as the soil is elevated ten to twelve inches above the water table. Hence, one will find "islands" of beech consociations in the *Quercus bicolor-Quercus palustris* lowland forest, occupying the somewhat higher land in the area. In its capabilities to invade, it is to the lowland forest what *Acer saccharum* is to the oak-hickory forest on the drier south-facing slopes of the upland, the two combining in the more favorable

TABLE 5

Strip transect in ten meter units, showing density of woody species in four size classes at station "A." (10 x 104 meters).

Species	Below 1 inch DBH 1 meter or over in height	1-10 inches	11-20 inches	21-30 inches	Total above 1 inch	Grand total
Acer rubrum	13	–	–	–	–	13
Acer saccharum	12	2	–	–	2	14
Amelanchier canadensis	1	1	–	–	1	2
Benzoin aestivale	1	–	–	–	–	1
Carpinus caroliniana	96	5	–	–	5	101
Carya cordiformis	31	–	–	–	–	31
C. glabra	1	–	–	–	–	1
C. laciniosa	21	3	–	–	3	24
Castanea dentata	1	1	–	–	1	2
Cornus florida	26	4	–	–	4	30
Corylus americana	147	1	–	–	1	148
Fagus grandifolia	8	7	12	2	21	29
Fraxinus americana	10	–	–	–	–	10
Hamamelis virginiana	13	–	–	–	–	13
Juglans nigra	2	–	–	–	–	2
Juniperus virginiana	1	–	–	–	–	1
Liriodendron tulipifera	40	5	–	–	5	45
Nyssa sylvatica	18	1	–	–	1	19
Ostrya virginiana	202	23	–	–	23	225
Populus grandidentata	14	2	–	–	2	16
Prunus serotina	9	1	–	–	1	10
Quercus alba	68	17	–	–	17	85
Q. borealis maxima	19	1	–	–	1	20
Rhus copallina	7	–	–	–	–	7
Ribes sp.	20	–	–	–	–	20
Rubus allegheniensis	45	–	–	–	–	45
Sassafras variifolium	37	2	–	–	2	37
Viburnum acerifolium	109	–	–	–	–	109
Vitis aestivale	18	–	–	–	–	18

habitat to a more or less pronounced beech-maple climax. *Benzoin aestivale* occupies the position in these transition areas which *Viburnum acerifolium* occupies in the typical mesophytic forest.

The old Pleistocene river terraces, while but ten to twenty feet above the lowland, support a climax vegetation similar to that at station "F" on north-facing slopes. The old trees on these river terraces (Table 5) are nearly all *Fagus grandifolia*, and they, consequently, form the topmost layer of the forest. The commercially more valuable timber trees, i.e. *Quercus alba*, and *Leriodendron tulipifera* were cut years ago and the less valuable beech was left, giving the forest the appearance of a beech consociation. However, in the tabulation the young growth reflects the original composition of the forest (Table 5). In the transect comprising 1,040 square meters, twenty beech were in the ten to twenty inch size class. Such species as *Liriodendron tulipifera* with five stems in the one to ten inch size class and *Quercus alba* with 17 stems in the same class indicate a more prominent participation of these species in the occupation of the crown cover as time goes on, and if one considers the smallest size class, this indication is even more evident. The high density of such species as *Corylus americana* and *Ostrya virginiana* indicate disturbance in the forest composition and are probably indicators of selective cutting with resultant open spaces.

As a whole, the composition of the forest points to a mixed hardwoods rather than to a beech-maple climax, at least for the present, in this respect, too, reflecting the forest on north-facing slopes of the upland.

The peculiar "island" like beech consociation are also features in the tran-

TABLE 6

Strip transect in ten meter units, showing density of woody species in four size classes at station "X." (10 x 110 meters).

Species	Below 1 inch DBH 1 meter or over in height	1-10 inches	11-20 inches	21-30 inches	Total above 1 inch	Grand total
Acer rubrum	2	–	–	–	–	2
Acer saccharum	9	1	1	–	2	11
Amelanchier canadensis	–	1	–	–	1	1
Benzoin aestivale	1	–	–	–	–	1
Carpinus caroliniana	19	9	–	–	9	28
Carya laciniosa	9	1	–	–	1	10
Cornus florida	–	1	–	–	1	1
Fagus grandifolia	163	104	16	1	121	284
Fraxinus americana	11	4	–	–	4	15
Fraxinus lanceolata	–	2	–	–	2	2
Liriodendron tulipifera	2	–	–	–	–	2
Prunus serotina	–	1	–	–	1	1
Quercus borealis maxima	1	3	–	–	3	4
Ulmus racemosa	11	6	–	–	6	17

sition lowland forest. Table 6 shows the composition of such a consociation at station "X," an area close to station "E," but mainly along the higher banks of little intermittent streams. Not only does *Fagus* control all the present top layer of the forest, but the dense reproduction points to a continuation of this dominance (Fig. 7). *Fagus grandifolia* is represented by 121 stems above one inch DBH, while all other species combined have only 32 stems. The same general aspect is shown by the younger growth. The second layer is here dominated by *Carpinus caroliniana.*

Both upland and lowland forest, thus, show the influence of topography upon the type of vegetation which will dominate. Of the two sub-climax forests *(Quercvus bicolor-Quercus palustris* and oak-hickory) the oak-hickory forest will probably endure the longer in this region because in old age topography as in Monroe county, changes by cutting of streams, are and will be slow.

Summary and Conclusion

1. The investigation was conducted in Salt Creek township, Monroe county, Indiana.

2. The area includes lowland and upland forest types.

3. Apparently no virgin timber remains in the township.

4. The present forested areas are limited to lands least suitable to agriculture, i.e. dry uplands and wet lowlands.

5. *Acer rubrum, Quercus bicolor, Q. palustris* are the most prominent members of the lowland associes with *Alnus rugosa* as a common species in early shrub succession.

6. Topography controls the forest types.

7. Oak-hickory constitutes the sub-climax forest on south-facing slopes.

8. A mixed hardwoods forest with beech-maple tendencies constitutes the climax on well-drained lowlands and north-facing slopes on the uplands.

9. *Fagus* is an early invader of the lowland forest, frequently forming "island-like" consociations.

10. *Acer saccharum* is an early invader of the south-facing slopes.

11. The oak-hickory is composed of markedly less number of species than the mixed hardwoods of north-facing slopes.

12. Nomenclature is that of Gray's Manual, 7th ed.

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SHRUBS OF CHEBOYGAN AND EMMET COUNTIES, MICHIGAN

RUSSELL LEE WALP

Introduction and Acknowledgements

During the summers of 1930, 1931, and ten days in the middle of May 1931 collection of shrubs of Emmet and Cheboygan counties were made. The collecting was done in the vicinity of the University of Michigan Biological Station, the keying out and the checking of the identifications was done at the University of Michigan Herbarium. Since a floral key would be of little value to the summer student or research worker, the keys are based upon foliage characteristics. Sets of the specimens collected were given to the University of Michigan Herbarium and to the University of Michigan Biological Station Herbarium. A set has also been retained in the writer's personal Herbarium.

The total number of shrubs reported for this region as compiled from various sources is about 140 species, but this number has been reduced because of the lack of specimens to substantiate some of the records. The following shrubs *Spirea latifolia, Sorbus subvestita, Vaccinium vacillans, Vaccinium corymbosum, Vaccinium uliginosum, Salix pyrifolia, Viburnum pubescens* and *Rubus randii* have been reported by others for the two counties, but as there appear to be no collections to verify them, they have been omitted. Cultivated shrubs have not been included unless they have spread from their original planting and become established elsewhere.

The number of shrubs for Emmet and Cheboygan counties as thus limited is 128 specimens and 22 varieties or a total of 150. Twenty-five of the shrubs which are found in Cheboygan County are not found in Emmet County, and there are only 5 shrubs found in Emmet County which are not found in Cheboygan County. Two factors are responsible for this uneven distribution; first, Cheboygan County has been botanically surveyed more carefully than Emmet County; secondly, Cheboygan County has all the ecological communities that Emmet County has besides a very large jack pine plains area, which is absent in Emmet County.

In the preparation of this paper Rosendahl and Butters' recent publication "Trees and Shrubs of Minnesota" was followed for nomenclature and sequence of families.

The author wishes to thank Dr. J. H. Ehlers, under whom the work was done, for many helpful suggestions and encouragement. He also wished to express his appreciation of the aid of Dr. C. R. Ball, Dr. E. W. Erlanson, and Dr. K. M. Wiegand for checking over material of Salix, Rosa, and Amelanchier. He is also indebted to Dr. F. C. Gates for supplying data concerning habitats and to Mr. Arthur Blickle for checking the keys.

Capital letter "C" indicates that the shrub is found in Cheboygan County

and "E," Emmet County. An asterisk is used to indicate that the shrub has not been previously reported: in parentheses (*) if the shrub has not been found by the author but has been collected by others than Gates or Ehlers. Parentheses are used around "E" or "C" whenever the shrub has formerly been reported under another name which is now used as applying to a different plant.

Key to the Genera Based upon Mature Foliage Characteristics

Leaves evergreen and persistent.
- Leaves linear, scale-like or awl-shaped.
  - Leaves glabrous.
    - Leaves opposite or in whorls of 3, dark green ---- *Juniperus*
    - Leaves alternate, yellow-green ---- *Taxus*
  - Leaves tomentose ---- *Hudsonia*
- Leaves broad, usually more than 3mm. wide.
  - Shrubs less than 9 cm. high, usually trailing or creeping.
    - Stem more than 4 mm. in diameter, margins of leaves ciliate.
      - Leaves 15-40 mm. wide, branches and leaves covered with glandular hairs ---- *Epigaea*
      - Leaves 5-15 mm. wide, if branches and leaves pubescent they are non-glandular ---- *Arctostaphylos*
    - Stem less than 4 mm. in diameter, margins of leaves not ciliate
      - Branches and leaves set with rigid spines, aromatic ---- *Chiogenes*
      - Branches and leaves without spines, not aromatic ---- *Vaccinium*
  - Shrubs more than 10 cm. high, neither trailing nor creeping.
    - Leaf margin entire.
      - Leaves densely wooly beneath (brown on old leaves) ---- *Ledum*
      - Leaves not densely wooly beneath, but may be white pubescent or glaucous.
        - Leaves sessile or nearly so, lower midrib glandular ---- *Kalmia*
        - Leaves petioled, lower midrib not glandular ---- *Andromeda*
    - Leaf margin serrate or denticulate.
      - Low shrubs, scarcely woody, leaves not scurfy and scaly.
        - Leaves round to obtusely wedge-shaped, margins obscurely serrate, aromatic ---- *Gaultheria*
        - Leaves narrowly wedge-shaped, sharply serrate, not aromatic ---- *Chimaphila*
      - Medium size bog shrub, decidedly woody, leaves covered with scurfy scales beneath ---- *Chamaedaphne*

Leaves not evergreen, deciduous.
- Leaves alternate.
  - Leaves compound.
    - Erect shrubs.
      - Leaflets entire.
        - Low shrubs, leaves 5-9—foliate ---- *Potentilla*
        - Small tree, or high shrub, leaves 11-25—foliate ---- *Robinia*
      - Leaflets serrate or dentate.
        - Stipulate.
          - Stipules adnate to petiole ---- *Rosa*
          - Stipules free.
            - Leaflets 3-5, branches usually prickly ---- *Rubus*
            - Leaflets 13-21, not prickly ---- *Sorbaria*
        - Exstipulate or stipules early deciduous.
          - Sap milky, rachis not glandular ---- *Rhus*
          - Sap not milky, rachis glandular ---- *Sorbus*

Vines, climbing or creeping.
Three-foliate ---------- *Rhus*
Five-foliate ---------- *Psedera*
Leaves simple.
Erect shrubs.
Buds covered with a single bud scale ---------- *Salix*
Buds covered with two or more scales.
Leaves entire.
Leaves with resinous dots beneath ---------- *Gaylussacia*
Leaves without resinous dots beneath.
Branches and branchlets "socket-jointed" at the nodes, bark very tough ---------- *Dirca*
Not as above.
Petiole more than 8 mm. long.
Leaves pubescent or puberulent beneath, acuminate at apex ---------- *Cornus*
Leaves glabrous beneath, mucronate, petiole purple ---------- *Nemopanthus*
Petiole less than 2 mm. long or leaves sessile--- *Vaccinium*
Leaves serrate or serrulate.
Tall shrubs or small trees armed with thorns over 2 cm. long ---------- *Crataegus*
Not armed with thorns, but often armed with prickles.
Leaves lobed.
Petiole pubescent with stellate hairs, bark shredding ---------- *Physocarpus*
Petiole without stellate hairs, bark not shredding.
Shrubs armed with prickles ---------- *Ribes*
Shrubs unarmed.
Leaves linear lanceolate and aromatic--- *Comptonia*
Leaves otherwise.
Exstipulate, leaves less than 7 cm. long--*Ribes*
Stipulate, leaves over 7 cm. long ---------- *Rubus*
Leaves not lobed.
Leaves triple-nerved ---------- *Ceanothus*
Leaves with single prominent nerve.
Leaves and branches resinous dotted.
Leaves linear lanceolate, stipulate ---------- *Comptonia*
Leaves otherwise, exstipulate or stipules early deciduous.
Leaves dentate above the middle only, aromatic ---------- *Myrica*
Leaves crenate serrate from below the middle, not aromatic ---------- *Betula*
Leaves and branches not resinous dotted.
Petiole glandular ---------- *Prunus*
Petiole not glandular.
Pith of stem triangular ---------- *Alnus*
Pith cylindrical.
Leaf margins wavy-toothed, teeth 1 to the cm. ---------- *Hamamelis*
Leaf margins more finely serrate.
Leaves narrow to oblanceolate and less than 2 cm. broad.
Petiole less than 5 mm. long--*Spiraea*
Petiole more than 6 mm. long--*Prunus*
Leaves not as above and more than 2.2 cm. broad.

Exstipulate or stipules minute or early deciduous, high shrubs.
Mature petiole more than 12 mm. long, fruit a berry-like pome ---------- *Amelanchier*
Mature petiole less than 12 mm. long, fruit otherwise.
Leaves acute at the base, one bundle scar ---------- *Ilex*
Leaves cordate or rounded at the base ---------- *Corylus*
Stipulate, fruit black, low shrubs, 3 bundle scars ---------- *Rhamnus*

Climbing or twining vines.
Stem unarmed, leaves not parallel veined.
Leaf blade about as broad as long, branchlets with tendrils ---- *Vitis*
Leaf blade longer than broad, branchlets without tendrils ---- *Celastrus*
Stem armed, leaves parallel veined ---------- *Smilax*

Leaves opposite or whorled.
Leaves simple.
Leaves lobed.
Stipulate, margins of leaves dentate, fruit a drupe ---------- *Viburnum*
Exstipulate, margins serrate, fruit a samara ---------- *Acer*
Leaves not lobed.
Leaf margins entire.
Branchlets and lower side of leaves covered with silvery and reddish fringed scales ---------- *Shepherdia*
Branchlets and leaves not as above.
Leaves pellucid-punctate or black dotted ---------- *Hypericum*
Leaves not as above.
Petiole over 8 mm. long.
Leaves in whorls or opposite, stipules persistent and brown ---------- *Cephalanthus*
Leaves opposite, stipules deciduous ---------- *Cornus*
Petiole less than 8 mm. long.
Pith solid in old stems, climbing or erect shrubs over .5 m. high ---------- *Lonicera*
Pith chambered in old branches, shrubs less than .6 m. high ---------- *Symphoricarpus*
Leaf margin serrate or dentate.
Shrubs less than 1 m. high, twigs marked with 2 hispid lines ---------- *Diervilla*
Shrubs over 1 m. high, twigs without 2 narrow hispid lines ---------- *Viburnum*

Leaves pinnately compound ---------- *Sambucus*

Annotated List of the Species of Shrubs Found in Emmet and Cheboygan Counties with Keys

Taxaceae

1. *Taxus canadensis* Marsh.—American Yew.
Common in cedar bogs and often in wet places in the hardwoods. Grapevine Point and North Fishtail, Douglas Lake. C.E.

Pinaceae

Key to Species of JUNIPERUS

Shrubs upright, leaves in whorls of 3 and awl-like ---------- *J. communis* var. *depressa*
Shrubs creeping, leaves opposite, scale-like on mature branches ---------- *J. horizontalis*

2. *Juniperus communis* var. *depressa* Pursh.—Prostrate Juniper.
Found in various situations, edge of bogs, roadsides, dunes and rarely in the aspens. C. E.

3. *Juniperus horizontalis* Moench—
Common on the dunes of Lake Michigan and Lake Huron. C.* E.

Liliaceae

4. *Smilax hispida* Muhl.—Prickly Greenbrier.
Not common. Found along lake shore and streams of Black Lake. C.

Salicaceae

Key to the Species of SALIX

Leaf margins entire or if sub-entire distantly and irregularly crenate-serrate.
  Leaves pubescent beneath.
    Leaves white wooly beneath ---------- *S. candida*
    Leaves grey-tomentosed beneath.
      Leaves elliptical to ovate, upper surface finely pubescent ------- *S. Bebbiana*
      Leaves narrow to broadly oblanceolate, upper surface glabrous except for the whitish mid-rib ---------- *S. humilis*
  Leaves glabrous beneath.
    Leaves entire, oblong and less than 5.5 cm. long---------- *S. pedicellaris*
    Leaves sub-entire to entire, obovate, over 5cm. long ---------- *S. discolor*
Leaf margins finely serrate or remotely denticulate.
  Leaf margins remotely denticulate ---------- *S. longifolia*
  Leaf margins finely serrate (if coarsely serrate try margins entire).
    Leaves narrow, less than 2 cm. wide (usually less than 1.5 cm.).
      Mature leaves glabrous or coppery pubescent ---------- *S. petiolaris*
      Mature leaves silvery or grey pubescent ---------- *S. subsericea*
    Leaves broad, over 2 cm. wide.
      Stipules peristent.
        Branchlets or twigs grey pubescent, dune plants.
          Leaves glossy and glabrate ---------- *S. glaucophylla*
          Leaves dull and pubescent ---------- *S. adenophylla*
        Branchlets or twigs glabrous, not dune plants ---------- *S. cordata*
      Stipules early deciduous.
        Leaves glaucous beneath, fruits in late summer ---------- *S. serissima*
        Leaves green beneath, fruits in spring ---------- *S. lucida*

5. *Salix lucida* Muhl.—Shining Willow.
Very common in various situations, bogs, lake shores, roadsides, banks of rivers and streams, wet meadows, etc. C. E.

5a. *Salix lucida* var. *intonsa* Fernald—
Found with the species and differing from it in that the lower surface of the leaves is thinly but permanently covered with copper colored hairs. C.* E.*

6. *Salix serissima* (Bailey) Fernald—Autumn Willow.
Quite common along margins of lakes, streams, and bogs. C. E.

7. *Salix longifolia* Muhl.—(*S. interior* Rowlee). Longleaf Willow.
Abundant especially on shores of inland lakes. Forms growing in the water are usually glabrous while those growing on the dunes are pubescent on both surfaces. C. E.

7a. *Salix longifolia* var. *Wheeleri* (Rowlee) Schneider.
Found along shores of Black Lake and Burt Lake. The leaves are broader and shorter and permanently pubescent. C.* E.*

8. *Salix pedicellaris* Pursh.—Bog Willow.
Infrequent. Found growing with Chamaedaphne as it invades the *Carex lasiocarpa* mat. Swales at Pine Point, Douglas Lake. C. E.

9. *Salix cordata* Muhl. Heart-leaved Willow.
Fairly common on the shores of Douglas Lake and Fairy Island. C.

10. *Salix glaucophylla* Bebb—
Found growing on sand dunes. The variety *brevifolia* was collected by Wheeler at Little Traverse Bay 1879. It is believed to be an ecological form by Schneider. C. E.

11. *Salix adenophylla* Hooker—Gland-Leaved Willow.
Usually found growing with *glaucophylla*. Forms occur at Cecil Bay on the dunes which likely are crosses with *S. candida*. C. E.

12. *Salix petiolaris* Smith—Slender Willow.
Very common in bogs, swales, along river and stream banks, roadsides and wherever the ground is wet. Mature specimens with coppery pubescence are frequently found. C. E.

13. *Salix subsericea* (Anders.) Schn.—
Formerly reported as *S. sericea* (9). Dr. C. R. Ball identified material as *S. subsericea*. It is not likely that the former extends this far north, although it has been reported farther south. (C.* E.*)

14. *Salix candida* Fluegge—Hoary Willow.
Frequent in bogs. Interesting forms grow on the banks of Nigger Creek. It likely crosses freely with *S. pedicellaris*, *S. discolor* and other species. C.* E.*

14a. *Salix candida* var. *denudata* Anders.—
Found growing with the species but differing from it in that the leaves are narrower and glabrate or glabrescent on both sides. C.* E.*

15. *Salix discolor* Muhl.—Pussy Willow.
Common. An interesting form grows in bogs which Dr. C. R. Ball says superficially resemble *S. hebecarpa* Fernald. This form has small, oblanceolate leaves, dark green above, glaucous beneath and in some specimens ferruginous pubescent beneath. C. E.

16. *Salix humilis* Marsh.—Prairie Willow.
More common than formerly supposed. Found growing in dry, sandy soil of the jack-pine and aspen plains. In this species the leaves vary greatly as to size, shape and pubescence. It is likely that the variety *rigidiuscula* Anders. is present and intergrades into the species. C. E.

17. *Salix Bebbiana* Sargent—Bebb Willow.
The most abundant and widely distributed willow in this region, found along streams, bogs, in aspens, jack pine plains, lake shores, etc. C. E.

17a. *Salix Bebbiana* var. *perrostrata* Rydberg—
Less abundant than the species, differing from it in that the leaves are glabrate. C.* E.*

Myricaceae

18. *Myrica Gale* L.—Sweet Gale.
Common in the low shrub association in bogs, along streams and lake shores. C. E.

19. *Comptonia asplenifolia* (L.) Ait.—Sweet Fern.
In dry sandy soil of the aspens. C.

Betulaceae

20. *Corylus rostrata* Ait.—Beaked Hazelnut.
Very common in the aspens and hardwoods. C. E.

21. *Betula pumila* var. *glandulifera* Regel—Dwarf Birch.
This shrub was formerly misunderstood and identified by Gates and Ehlers (1924) as *B. glandulosa*. Specimens collected at Mud Lake, Pine Point, east of Pelleston and north of Levering have the branchlets pubescent with scattered long, soft hairs and resiniferous or glandular dots, and the leaves have resiniferous or glandular dots on both surfaces and are slightly hairy on the midrib. These characters may vary more or less on the same plant. (C. E.)

22. *Alnus incana* (L.) Moench—Speckled Alder.
In wet acidic soil, border of bogs, lakes and streams where it is the commonest shrub in the high shrub association. C. E.

Saxifragaceae

Key to the Species of RIBES

Shrubs with nodal spines.
Nodal spines stout, berries smooth; young branches thickly covered with spines.
Leaves more or less pubescent at least on the petioles, peduncle pubescent ---------- *R. oxyacanthoides*
Leaves sparsely pubescent, petiole not glandular, peduncle glabrous--*R. hirtellum*
Nodal spines slender, fruit covered with prickly spines, young branches sparsely covered with prickly spines ---------- *R. Cynosbati*
Shrubs without nodal spines.
Stem and branches without thorns, fruit may be glandular but never bristly.
Leaves dotted on the underside with resinous sessile glands.
Leaves coarsely doubly serrate; racemes drooping and downy *R. americanum*
Leaves singly serrate, racemes upright and downy, berries dotted with sessile glands ---------- *R. hudsonianum*
Leaves not glandular beneath.
Petiole as long or nearly as long as the blade, berries stalked glandular ---------- *R. prostratum*
Petiole shorter than blade, berries glabrous ---------- *R. triste*
Stem with weak thorns and young branches covered with bristly prickles; fruit bristly ---------- *R. lacustre*

23. *Ribes lacustre* (Pers.) Poir.—Swamp Black Currant.
Commoner than formerly supposed, collected at Nigger Creek Bog, Reese's Bog, Limestone Creek and Cecile Bay. C.*E.*

24. *Ribes americanum* Mill.—Wild Black Currant.
Infrequent, collected at Reese's Bog and Limestone Creek. C. E.

25. *Ribes prostratum* L'Her.—
Infrequent in cedar bogs. Reese's and Riggesville Bogs. C. E.

26. *Ribes hudsonianum* Richards—Northern Black Currant.
Locally common at Mud Lake Bog, Reese's Bog and the gorge. C. E.*

27. *Ribes triste* Pall.—American Red Currant.
Common in cedar bogs and damp woods. C. E.

27a. *Ribes triste* var. *albinervium* (Michx.) Fernald—
As common as the species and differs from it in that the leaves are glabrous or glabrate beneath. C. E.

28. *Ribes Cynosbati* L.—
Very common; in the aspens, willow thickets, hardwoods, bogs, etc. C. E.

29. *Ribes oxyacanthoides* L.—Smooth Gooseberry.
Infrequent, hardwoods near Petoskey. C.* E.

30. *Ribes hirtellum* Michx.
Commoner than *R. oxyacanthoides* and appears to intergrade into it. C. E.

Hamamelidaceae

31. *Hamamelis virginiana* L.—Witch Hazel.
Infrequent; a few shrubs in aspens, at Nigger Creek and the gorge. C. E.

Rosaceae

32. *Physocarpus opulifolius* (L.) Maximowicz—Ninebark.
Infrequent; West Maple River and Wolverine. C.* E.

33. *Potentilla fruticosa* L.—Shrubby Cinquefoil.
Frequent in wet meadows in the jack pine plains, and along shores of Lake Michigan. C. E.

Key to the Species of RUBUS

Leaves compound, 3-7—foliate.
Leaves whitish beneath; berries fall away from the dry receptacle ___RASPBERRIES
Stem prickly and glaucous.
Prickles slender and straight, berries reddish purple_____*R. neglectus*
Prickles hooked and more glaucous stem, berries purple black *R. occidentalis*
Stem bristly, not glaucous, berries red _____*R. strigosus*
Leaves green beneath; ripe fruit not parted from receptacle _____
_____BLACKBERRIES AND DEWBERRIES
Low herbaceous-like shrub growing in low, wet, shady places _____*R. triflorus*
Very woody throughout and usually growing higher than 40 cm.
Stem erect or arching _____BLACKBERRIES
Stems usually unarmed or distantly armed leaves glabrous on both sides _____*R. canadensis*
Stems armed more or less with prickles, leaves velvety pubescent beneath _____*R. nigrobaccus*
Stem trailing or procumbent _____DEWBERRIES
Leaves dull above, prickles various, berries black _____*R. flagillaris*
Leaves shiny above, prickles all recurved, berries red _____*R. hispidus*
Leaves simple or palmately lobed.
Leaves 3-5-lobed, finely serrate; flowers purple and numerous _____*R. odoratus*
Leaves almost equally 5-lobed, coarsely serrate; flowers white and few *R. parviflorus*

34. *Rubus odoratus* L.—Purple Flowering Raspberry.
Very rare. The station from which it was reported by F. C. Gates has been cleared. E.

35. *Rubus parviflorus* Nutt.
Not as rare as the previous species, found in mixed woods at Big Stone Bay and at Limestone Creek. C.* E.

36. *Rubus nigrobaccus* L. H. Bailey—*(R. alleghaniensis* Porter).
Very common in dry sandy places. C. E.

37. *Rubus flagillaris* Willd.—*(R. villosus* Ait.).
Infrequent; collected in aspens at Black Lake and North Fishtail, Douglas Lake. C. E.

38. *Rubus strigosus* Michx.—*(R. idaeus* var. *aculeatissimus* R. & T.).
Very common, especially in recent burnt-over areas. C E.

39. *Rubus triflorus* Richards—Dwarf Red Blackberry.
Somewhat herbaceous, but the stems live over winter. Common in cedar bogs. C. E.

40. *Rubus occidentalis* L.
Cultivated; found once as an escape. C. E.

41. *Rubus neglectus* Peck—
Reported from the second growth hardwoods at Grapevine Point, Douglas Lake. C.

42. *Rubus hispidus* L.—
Infrequent; occurs on the edge of bogs, at the Wildwood jack pine plains, Reese's bog, and bogs west of Pellston. C. E.

43. *Rubus canadensis* L.—
Infrequent in cedar bogs. C. E.*

44. *Spiraea alba* DuRoi—(*S. salicifolia* L.). Meadow Sweet.
Found on low, moist ground throughout the two counties. C. E.

Key to the Species of Rosa

Infrastipular prickles present at the nodes.
  Hooked, stout infrastipular prickles over 6 mm. long, leaves fragrant, an escape from cultivation ---------- *R. rubiginosa*
  Infrastipular prickles slender and less than 6 mm. long, leaves often glandular but never fragrant ---------- Native Roses
    Infrastipular prickles curved, stems not armed at base.
      Grows in wet rich soil, hips glandular and sepals deciduous from the fruit ---------- *R. palustris*
      Grows in high poor soil, hips eglandular and sepals persistent in the fruit ---------- *R. palustriformis*
    Infrastipular prickles straight, bristly at the base ---------- *R. Schuetteana*
Infrastipular prickles absent at the nodes.
  Stem armed.
    Flowering lateral branches less than 10 cm. long.
      Leaflets singly toothed.
        Prickles stout, stipules usually red-tinged, habit coarse and erect, flowers usually 3 (seldom 1-7) ---------- *R. michiganensis*
        Not as above and the flowers in corymbs ---------- *R. blanda*
      Leaflets doubly toothed and glandular ---------- *R. acicularioides*
    Flowering branches over 10 cm. long.
      Leaflets usually 5-7, rarely 9.
        Leaflet margins singly or doubly coarsely serrate, underside of leaves usually glandular ---------- *R. acicularis*
        Leaflet margins singly and finely serrate, underside of leaves never glandular ---------- *R. michiganensis*
      Leaflets 9-11 ---------- *R. suffulta*
  Stem unarmed.
    Slender shrub, grows in wet, rich soil; leaflet margins finely serrate, hips glandular ---------- *R. palustris*
    Stout shrub, growing in poor, dry soil; leaflet margins coarsely serrate, hips not glandular ---------- *R. blanda*

45. *Rosa blanda* Ait.—
The species and its varieties are quite common especially on the lake shores. Flowers from June 3-18. C. E.

45a. *Rosa blanda* var. *alba* Schuette—
Differs from the species in that the petals are white.

45b. *Rosa blanda* var. *glandulosa* Schuette—
Differs from the species in that the hips are pyriform and the rachis, stipules, bracts and sepals are glandular.

45c. *Rosa blanda* var. *subgeminata* Schuette—
Differs from the species in that it has twin-prickles which are intermittent and irregular.

45d. *Rosa blanda* var. *hispida* Farwell—
Differs from the species in that the stem is bristly.

46. *Rosa Schuetteana* Erlanson—
This form was reported by Gates and Ehlers (1924) as *R. carolina* L. Douglas Lake is the type locality. The first collection was made by Mrs. C. C. Deam. Blooms 10 days earlier than *R. palustris*. C.

47. *Rosa michiganensis* Erlanson—
Type locality, Ammophila dunes on the east shore of Douglas Lake. Blooms 10 days later than *R. blanda*. C.

48. *Rosa suffulta* Green—
Infrequent, grows along the Cheboygan road. The first collection was made by J. H. Ehlers along the G.R.I. Railroad tracks in 1920. Flowers June 30-July 7. C. E.

49. *Rosa acicularis* Lindl.—
Shores of inland lakes and Lake Michigan. This species has several distinct varieties. Blooms May 30—June 8. C. E.

49a. *Rosa acicularis* var. *Bourgeauiana* Crepin—
Differs from the species in that the hips are subglobose and that the leaflets are glandular beneath, teeth glandular-compound.

49b. *Rosa acicularis* var. *rotunda* Erlanson—
Differs from the species in that the hips are subglobose, teeth of leaves simple and eglandular.

49c. *Rosa acicularis* var. *Sayiana* Erlanson—
Differs from the species in that the hips are ellipsoid and the leaflets glandular-granuliferous beneath.

49d. *Rosa acicularis* var. *lacorum* Erlanson—
This variety differs from the species and the above variety in that the hips are pyriform to elliptic, leaflets pubescent and the teeth glandular compound.

50. *Rosa palustriformis* Rydberg—
Collected at Indian River jack pine plains. C.

51. *Rosa palustris* Marsh.—
Less frequent than R. blanda and grows in richer and moister soil. Blooms from July 7-20. C. E.

51a. *Rosa palustris* var. *inermis* (Schuette) Erlanson—
Found growing on edge of bogs. Differs from the species in that the stem is unarmed.

52. *Rosa rubiginosa* L.—Sweetbrier.
An escape from cultivation growing in rocky places. Several bushes at Limestone Creek. Although it had been previously collected by J. H. Ehlers it was never recorded. C.* E.*

Key to the Species of ARONIA

Leaves, branchlets and fruit gray tomentose.
Fruit black or purple ---------- *A. floribunda*
Fruit red ---------- *A. arbutifolia*
Leaves, branchlets, and fruit glabrous ---------- *A. melanocarpa*

53. *Aronia arbutifolia* (L.) Ell.—
Locally common at Bryant's, Mud Lake and Lancaster Lake bogs. C. E.

54. *Aronia floribunda* (Lindley) Spach—(*Pyrus arbutifolia* var. *atropurpurea* Robs.)
Not as common as *A. arbutifolia* and intergrades into it. Lancaster Lake bogs. C. E.

55. *Aronia melanocarpa* (Michx.) Spach—(*Aronia nigra* (Willd.) Britton).
Infrequent, Mud Lake Bog. C. E.

56. *Sorbus americana Marsh.*—
Frequent in cedar bogs. C.* E.*

57. *Sorbaria sorbifolia* (L.) A. Br.—
An escape from cultivation. Roadside near Bliss. E.*

58. *Crataegus laurentiana* Sargent—
Shrub or small tree. Black Lake. C.

59. *Crataegus Boyntoni* Beadle—
Reported for central Michigan. Specimens collected from the Wildwood jack pine plains are very close to this species. C.*

60. *Crataegus rotundifolia* Moench—
Along Lake Shore Drive near Harbor Springs. E.

61. *Crataegus Crus-galli* L.
Reported by C. W. Fallas (unpublished) from Harbor Springs. E.

62. *Crataegus roanenis* Ashe—
Limestone Creek and near the Biological Station. C.

63. *Crataegus macrosperma* Ashe—
Large shrub or small tree growing at Colonial Point. C.

64. *Crataegus succulenta* Schrader—
A small tree growing on Colonial Point, Burt Lake. C.

65. *Crataegus* sp.
Shore of Lake Michigan near Middle Village. E.*

Key to the Pure Species of AMELANCHIER*

Teeth fine (5-12 teeth per cm.), summit of ovary glabrous.
  Leaves tomentose; teeth 6-10 per cm. ---------- *A. canadensis*
  Leaves glabrous; teeth 2-9 per cm. ---------- *A. laevis*
Teeth coarse and spreading (less than 5 teeth per cm.), summit of ovary tomentose (in *A. stolonifera* the teeth are often smaller).
  Leaves petioled, fruit in racemes.
    Leaves glabrous or nearly so; plants stoloniferous.
      Leaves oval-oblong, less than 20 teeth on a side ---------- *A. humilis*
      Leaves oval, more than 20 teeth on a side ---------- *A. stolonifera*
    Leaves tomentose; plants not stoloniferous ---------- *A. huronensis*
  Leaves nearly sessile; fruit almost solitary ---------- *A. Bartramiana*

66. *Amelanchier laevis* Wiegand—June-berry
The most common *Amelanchier* in this region, found in various situations. Formerly reported as *A. canadensis* (Gates and Ehlers, 1924). Crosses with other species very readily. C.* E.*

* In this genus all the species interbreed with each other. Over 80% of the specimens collected were hybrids and often the hybrids themselves cross with each other.

67. *Amelanchier canadensis* (L.) Medic.
Not as common as it is farther south in the state. Formerly thought to be rare, but the writer has shown it to be fairly common in the jack pine plains. C. E.

68. *Amelanchier stolonifera* Wiegand—
Locally common in the jack pine plains. C.*

69. *Amelanchier huronensis* Wiegand—
Next to *A. laevis* it is the most common, crossing readily with other species found here. C.* E.*

70. *Amelanchier Bartramiana* (Tausch) Roemer—
This species has not yet been found in the pure state, Wiegand says that the hybrids collected from the region indicate that it must be in the region. C.* E.*

71. *Amelanchier humilis* Wiegand—
This species according to Wiegand appears to be rare in Michigan. Collections were made at South Fishtail, Douglas Lake and at the Cheboygan Bridge. C. E.*

Key to the Species of PRUNUS

Dwarf shrubs, leaves narrow oblong to oblanceolate and not serrate at the base ---------- SAND CHERRIES
Low erect shubs, leaves spatulate-oblong, serrate above the middle, entire toward the cunate base ---------- *P. susquehanae*
Prostrate shrubs, leaves linear spatulate to oblanceolate, sub-entire, loosely toothed above the middle ---------- *P. pumila*
Large shrubs, leaves broad, never spatulate and serrate to the base.
Pith of stem flattened and brown; branches thorny or armed.
Leaves small, less than 4 cm. long, low shrubs in jack pine plains ---------- *P. alleghaniensis* var. *Davisii*
Leaves large, more than 5 cm. long; large shrubs ---------- *P. nigra*
Pith of stem oblong and whitish, branches unarmed.
Leaves oval to obovate, fruit black ---------- *P. virginiana*
Leaves oblong-lanceolate, fruit red ---------- *P. pennsylvanica*

72. *Prunus virginiana* L.—
Sometimes a small tree, very common throughout. C. E.

72a. *Prunus virginiana* var. *demissa* f. *pachyrrachis* Sargent—
This form differs from the species in that it is permanently pubescent on the lower surface of the leaf and petiole, and the leaves are not cordate at the base. Wildwood jack pine plains.

73. *Prunus nigra* Ait. Canada Plum.
Often a small tree. Grapevine Point, Douglas Lake; Goodhart; and shore of Burt Lake. C. E.*

74. *Prunus pennsylvanica* L.f.—Pin Cherry.
Tall shrub or small tree. Abundant in burnt over land. C. E.

75. *Prunus susquehanae* Willd.—
Jack pine plains at Indian River, Wildwood and Black Lake. C.

76. *Prunus pumila* L.—Sand Cherry.
Common on sandy lake shores. Lake Michigan, Lake Huron and Douglas Lake. C. E.

77. *Prunus alleghaniensis* var. *Davisii* Wight—
Rare. Found infrequently in Wildwood jack pine plains and near village of Indian River. C.

Leguminosae

78. *Robinia viscosa Vent.*—Clammy Locust.
Often a small tree. Escape along Nigger Creek Road. C. E.

Anacardiaceae

Key to the Species of RHUS

Erect shrubs; leaves pinnately compound.
Leaves glabrous beneath, or pubescent only along the veins.
Branches, twigs and petioles sparsely pubescent _____*R. glabra*
Branches, twigs and petioles densely pilose pubescent _____*R. typhina*
Leaves soft pubescent above and beneath, as well as on the branches and petioles _____*R. glabra* var. *borealis*
Sub-erect or vines, leaves pinnately tri-foliate _____*R. toxicodendron*

79. *Rhus typhina* L.—
Rare; reported by J. H. Ehlers. C. E.

80. *Rhus glabra* L.—
Infrequent in the aspens. C. E.

80a. *Rhus glabra* var. *borealis* Britton.
Very common, especially in the aspens. Differs from the species in that the leaves are pubescent on the underside; varies from 2-20 feet in height. C. E.

81. *Rhus toxicodendron* L.—
Common throughout the two counties. Varies considerably and on the dunes it may be found growing erect. C. E.

Aquifoliaceae

82. *Ilex verticillata* (L.) Gray—Virginia Winter-berry.
Common in thickets on the margin of bogs and streams. C. E.

82a. *Ilex verticillata* var. *tenuifolia* (Torrs.) Wats.—
Intergrades into the species and differs from it in that the leaves are thinner and the fertile flowers are inclined to be solitary. C.*

83. *Nemopanthus mucronata* (L.) Trel.—Mountain Holly.
Frequent in bog-thickets and occasionally in the aspens and hardwoods. C. E

Celastraceae

84. *Euonymus* sp.
Reported by F. C. Gates in beech-maple forest. He describes it as low-creeping in habit like *E. obovatus* and leaves like *E. americana*. C.

85. *Celastrus scandens* L.—Climbing Bittersweet.
Abundant, especially on Grapevine Point and dunes at Sturgeon Bay. C. E.

Aceraceae

Key to the Species of ACER

Bark striped, leaves finely serrate and sparsely pubescent when young, petiole

brown-pubescent above, racemes drooping ---------- *A. pennsylvanicum*
Bark not striped, leaves coarsely serrate, pubescent twigs and buds, racemes erect ---------- *A. spicatum*

86. *Acer spicatum* Lam.—Mountain Maple.
Moist, damp woods, especially in the Picea-Abies association. C. E.

87. *Acer pennsylvanicum* L.—Striped Maple.
Under shrub in the hardwoods and on the margins of cedar bogs. C. E.

Rhamnaceae

88. *Rhamnus alnifolia* L'Her. Dwarf Alder.
Common on edge of cedar bogs, tamarack bogs and dune bogs. C. E.

Key to the Species of CEANOTHUS

Leaves oblong or elliptic-lanceolate, glabrous or nearly so ---------- *C. ovatus*
Leaves ovate or ovate-oblong, pubescent ---------- *C. americanus*

89. *Ceanothus ovatus* Desf.—Small Red-root.
Infrequent and usually found growing with *C. americanus*. Jack pine plains at Indian River, Wildwood and Black Lake. C.

90. *Ceanothus americanus* L.—New Jersey Tea.
Commoner than *C. ovatus*, and found in similar situations. C.

Vitaceae

91. *Vitis vulpina* L.—
Common, especially at Grapevine Point, Douglas Lake; specimens collected here often have unripe fruit measuring 10 mm. to 13 mm. in diameter. C. E.

92. *Parthenocissus quinquefolia* (L.) Planch.—
Infrequent. Found in cedar bogs at North Fishtail, Douglas Lake; and Wolverine Fire Tower Bog. All specimens examined and collected appear to be the variety *hirsuta* as the foliage is pubescent. C. E.

Hypericaceae

93. *Hypericum Kalmianum* L.
Locally common at Cecil Bay and shore of Lake Huron. C. E.

Cistaceae

94. *Hudsonia tomentosa* Nutt.—
Rare; J. H. Ehlers collected this shrub from the jack pine plains near Black Lake in 1924. It has not been reported since. C.

Thymelaeaceae

95. *Dirca palustris* L.—
Infrequent, but locally common in Black Lake and Burt Lake hardwoods. C.

Elaeagnaceae

96. *Shepherdia canadensis* (L.) Nutt.
Common, found in dry places, most abundant along the shores of Lake Michigan and Lake Huron, and occasionally found in the aspens at Douglas Lake. C. E.

Cornaceae

Key to the Species of CORNUS

Leaves opposite.
Pith of one and two year old stems white.

Leaves at least twice as long as wide, ovate to lanceolate.
Pubescence of stems, leaves and inflorescences usually closely appressed throughout _____ *C. stolonifera*
Pubescence of stem, leaves and inflorescences usually thick and wooly throughout _____ *C. Baileyi*
Leaves nearly as long as wide, broadly ovate to orbicular _____ *C. rugosa*
Pith of one and two year old stems brown.
Branches brown, last year's growth pubescent, fruit blue _____ *C. obliqua*
Branches grey, last year's growth glaberate, fruit white _____ *C. candidissima*
Leaves alternate or in fascicles _____ *C. alternifolia*

97. *Cornus alternifolia* L.f.—Alternate-leaved Dogwood.
Not common. Occasionally in the aspens. Gorge and North Fishtail Bay, Douglas Lake. C .E.

98. *Cornus obliqua* Raf.—
North shores of Douglas Lake at Deer Bay and Ingleside. Formerly confused with C. *ammomum* Miller which has reddish trichomes on its under surface. C.E.

99. *Cornus rugosa* Lam.—*(C. circinata* L'Her.).
Abundant in the aspens, especially at Cecil Bay and Grapevine Point. C. E.

100. *Cornus candidissma* Marsh.—*(C. paniculata* L'Her.).
Infrequent. Wildwood jack pine plains. C.

101. *Cornus stolonifera* Michx.—Red Osier Dogwood.
Very common in low, wet places. C. E.

102. *Cornus Baileyi* Coulter & Evans—
Grows with C. *stolonifera* and evidently hybridizes with it as many plants in this region cannot definitely be classified as one or the other. C. E.

Ericaceae

103. *Chimaphila umbellata* var. *cisatlantica* Blake—
Low, semi-herbaceous shrub; frequent in the aspens. C. E.

104. *Ledum groenlandicum* Oeder—Labrador Tea.
Common in Chamaedaphne, cedar and tamarack bogs. C. E.

105. *Kalmia angustifolia* L.—
Rare; collected by J. H. Ehlers at Riggesville Bog in 1926. Has not been seen since. C.

106. *Kalmia polifolia* Wang.
Frequent in Chamaedaphne bogs; differs from the preceding in that the leaves are glaucous beneath instead of green. C. E.

107. *Epigaea repens* L.—Trailing Arbutus.
In aspens and cedar bogs. C. E.

108. *Chamaedaphne calyculata* (L.) Moench—
Very common throughout the two counties, invading the *Carex lasiocarpa* mat and eventually forming its own association. C. E.

109. *Andromeda glaucophylla* Link—
Growing in bogs with *Kalmia* and *Chamaedaphne*. C. E.

110. *Arctostaphylos Uva-ursi* (L.) Spreng.—
Low ground shrub in the aspens and dunes along the shore of Lake Michigan and Douglas Lake. C. E.

110a. *Arctostaphylos Uva-ursi* var. *coactilis* Fernald & Macbride—
Found growing with the species and differing from it in that the young twigs are not viscid, and that they are persistently canescent-tomentulose. C.* E.*

111. *Chiogenes hispidula* (L.) T. & G.—Creeping Snowberry.
Common in wet coniferous woods and cedar bogs. C. E.

112. *Gaylussacia baccata* (Wang) K. Koch—Huckleberry.
Common in dry sandy soil throughout the two counties. C. E.

112a. *Gaylussacia baccata* f. *glaucocarpa* (Robinson) Mackenzie—
Has been found at Bryant's Bog.

Key to the Species of VACCINIUM

Upright shrubs, leaves 1.5 cm. to 4 cm. long. ---------- CYANOCOCCUS GROUP
Leaves glabrous, or only pubescent along the mid-rib
Leaves green above and below ---------- *V. pennsylvanicum*
Leaves green above and glaucous beneath ---------- *V. pennsylvanicum* var. *nigrum*
Leaves pubescent above and below ---------- *V. canadense*
Slender, trailing, creeping shrubs; leaves 4 mm. - 15 mm. long ---- OXYCOCCUS GROUP
Leaves ovate-lanceolate, underside white; berries less than 1 cm in diameter
---------- *V. oxycoccus*
Leaves elliptical, underside of leaves pale and glaucous, berries more than 1 cm. in diameter ---------- *V. macrocarpon*

113. *Vaccinium pennsylvanicum* Lam.—
Very common in the aspens, especially burnt over areas. C. E.

113a. *Vaccinium pennsylvanicum* var. *nigrum* Wood—
Less abundant than the species and found growing with it. C. E.

114. *Vaccinium canadense* Kalm—
Common in dry, sandy situations as well as on margins of bogs. J. H. Ehlers reported a black berried form of this species in 1918. The white berried form has also been collected once or twice at North Fishtail, Douglas Lake. C. E.

115. *Vaccinium oxycoccus* L.—
Common in Chamaedaphne and cedar bogs. C. E.

116. *Vaccinium macrocarpon* Ait.—
Less common than *V. oxycoccus* and found growing in similar situations. Mud Lake and Riggesville bogs. C. E.

Rubiaceae

117. *Cephalanthus occidentalis* L.—Buttonbush.
Rare. Along bog streams of Black Lake. C.

Caprifoliaceae

Key to the Species of SAMBUCUS

Pith white, fruit black, flowers midsummer ---------- *S. canadensis*
Pith brown, fruit red, flowers early spring ---------- *S. pubens*

118. *Sambucus pubens* Michx.
Very common. C. E.

119. *Sambucus canadensis* L.—Common Elder
Infrequent, found at Ingleside, Bessey Creek and along the Cheboygan road. C. E.

Key to the Species of VIBURNUM

Leaves lobed.
Branches brown, branchlets and petioles pubescent, petiole eglandular, fruit black ---------- *V. acerifolium*
Branches grey, branchlets and petioles glabrous, petiole glandular, fruit red ---------- *V. trilobum*
Leaves serrate, not lobed.
Buds scurfy punctate; leaves short acuminate at the apex, crenulate and often obscurely serrate; cymes peduncled ---------- *V. cassinoides*
Buds not scurfy punctate, leaves long acuminate at apex, cymes not peduncled ---------- *V. Lentago*

120. *Viburnum trilobum* Marsh.—*(V. Opulus* var. *americanum* (Miller) Ait.).
Infrequent in bogs and low ground. C. E.

121. *Viburnum Lentago* L.—Black Haw.
Found along streams and lake shores where the soil is rich. C. E.

122. *Viburnum acerifolium* L.—Maple-leaved Arrow-wood.
Infrequent; found in the aspens and the gorge. C.

123. *Viburnum cassinoides* L.—
Very common in the shrub zone bordering bogs. C. E.

124. *Symphoricarpos albus* (L.) Blake—
Commoner in this region than formerly supposed. Found in the jack pine plains at Black Lake and Wildwood, and along the dunes at Sturgeon Bay. Several specimens collected tend to intergrade into the variety *pauciflorus* (Robbins) Blake. C. E.*

Key to the Species of LONICERA

Erect shrubs.
Leaves ovate-oblong and margins ciliate ---------- *L. canadensis*
Leaves oblong and margins not ciliate ---------- *L. oblongifolia*
Climbing or twining shrubs.
Margins of leaves ciliate ---------- *L. hirsuta*
Margins of leaves not ciliate.
Leaves nearly or quite glabrous beneath, fruit salmon color ---------- *L. dioica*
Leaves pubescent beneath, fruit red ---------- *L. dioica glaucescens*

125. *Lonicera dioica* L.—
Climbing but erect when there is no support for it to climb over. Found along lake shores, bogs and thickets. C. E.

125a. *Lonicera dioica* var. *glaucescens* (Rydb.) Butters—
This variety does not seem to warrant specific rank as many of the plants grade into the species.

126. *Lonicera oblongifolia* (Goldie) Hook.—
Common in bogs and thickets. C. E.

127. *Lonicera canadensis* Marsh.—
Frequent in aspens and hard woods where the ground is moist. C. E.

128. *Diervilla lonicera* Miller—
Very abundant in the aspens and cleared, cut-over hardwoods. C. E.

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MARIETTA COLLEGE,
MARIETTA, OHIO.

NOTES ON THE FLORA OF THE INDIANA DUNES

CARL A. BUHL *

Several articles and many unpublished data concerning the flora of the Indiana Dunes, make advisable a list to indicate our present botanical knowledge of this region and thus provide a basis for future investigation. Since the *Flora of the Indiana Dunes* by D. C. Peattie, published in 1930, is the last comprehensive work concerned with the whole flora of the dune region, it is used as a basis for the flora known at that time. All additions and corrections to Peattie's Flora and all other reports from the Indiana Dunes considered incorrect because of change in nomenclature, original erroneous identification of specimens, indistinctness of varieties, or lack of confirming specimens, are recorded. Changes due merely to revised nomenclatorial concepts are not included. Forms also have not been mentioned. All relevant reports have been cited except for Deam's reports on the trees and shrubs of Indiana, where only the latest and most accurate editions have been used. To bring the Indiana Dunes Region completely within my amended "Chicago Area" the insignificant portion found in La Porte County is omitted. The following symbols indicate the herbaria containing specimens confirming the additions.

B	Butler University Herbarium	L	Marcus Ward Lyon Herbarium
D	Charles Clemon Deam Herbarium	M	Missouri Botanical Garden Herbarium
F	Field Museum Herbarium	N	National Herbarium, National Museum
G	Gray Herbarium, Harvard Univ.	ND	Notre Dame University Herbarium
I	University of Illinois Herbarium	W	University of Wisconsin Herbarium

I am indebted to Mr. C. C. Deam, Dr. N. C. Fassett, Dr. J. M. Greenman, Dr. Theodor Just, Dr M. W. Lyon, Dr. B. L. Robinson, and Dr. P. C. Standley, for use of and information concerning specimens in the herbaria under their supervision; and especially to Mr. C. C. Deam, Dr. Theodor Just, and Mr. D. C. Peattie for reading the manuscript and offering many helpful suggestions.

Additions to the Flora of the Indiana Dunes

Athyrium angustifolium (Michaux) Milde. (F).
Botrychium dissectum Sprengel. (23) (L, ND).
Equisetum nelsoni (Eaton) Schaffner. (10) (D).
Sparganium angustifolium Michaux. (31 as *S. simplex)* (I, ND).
Sparganium chlorocarpum Rydberg. (D).
Panicum deamii Hitchcock & Chase. (11) (D, N).
Panicum lindheimeri var. *septentrionale* Fernald. (11) (G).
Stipa avenacea Linnaeus. (23, 31) (L).
Sporobolus neglectus Nash. (D).

* This paper is the last contribution of Mr. C. A. Buhl who died on Jan. 15, 1935, at the age of 21 just before graduation from the University of Chicago. Mr. Charles C. Deam of Bluffton, Ind., assisted materially by constructive criticism and by reading the proof. This service is gratefully acknowledged as a last tribute to a young fellow botanist.—The Editor.

Sphenopholis obtusata (Michaux) Lamson-Scribner. (11) (F).
Triplasis purpurea (Walter) Chapman. (12) (D).
Poa debilis Torrey. (20, 25) (L).
Glyceria pallida (Torrey) Trinius. (25, 31) (L).
Festuca elatior Linnaeus. (11) (F, I).
Elymus virginicus var. *jejunis* (Romalay) Bush. (4, 11) (D).
Elymus virginicus var. *submuticus* Hooker. (11) (D).
Scirpus cyperinus var. *condensatus* Fernald. (31, 33) (D, I).
Carex hassei Bailey. (10) (D).
Carex limosa Linnaeus. (31) (F).
Carex shriveri Britton. (D).
Commelina angustifolia Michaux. (D, L as *C. longicaulis).*
Pontederia cordata var. *angustifolia* Torrey. (27) (N).
Juncus effusus var. *pylaei* (Laharpe) Fernald & Wiegand. (W).
Erythronium americanum Ker. (23) (L).
Spiranthes lucida (Eaton) Ames. (F).
Ostrya virginiana var. *glandulosa* Sargent. (13) (F).
Pilea fontana (Lunell) Rydberg. (24, 25) (ND).
Comandra richardsiana Fernald. (23, 30, 31) (L).
Polygonum awaits a rational treatment of the many described varieties.
Chenopodium lanceolatum Muhlenberg. (D).
Corispermum nitidum Kitaibel. (33) (D, F).
Silene csereii Baumgarten. (17) (W).
Silene virginica Linnaeus. (19, 30, 31) (I).
Thalictrum dasycarpum Fischer & Lallemont. (31) (W).
Brassica arvensis (Linnaeus) Kuntze. (F).
Rubus idaeus var. *canadensis* Richardson. (14) (D).
Robinia hispida Linnaeus. (21) (D).
Lathyrus venosus var. *intonsus* Butters & St. John. (12) (D).
Tribulus terrestris Linnaeus. (22) (D).
Acer negundo var. *violaceum* Kirchner. (13) (L).
Helianthemum bicknellii Fernald. (23 as *H. walkedae)* (L).
Didiplis diandra (Nuttall) Wood. (F).
Angelica atropurpurea Linnaeus. (D).
Lythrum salicaria Linnaeus. (31) (W).
Fraxinus lanceolata Borkhausen. (13) (F).
Apocynum hypericifolium var. *farwellii* (Greene) Woodson. (D).
Cynoglossum virginianum Linnaeus. (31) (F, W).
Physostegia speciosa Sweet. (23) (D, L).
Satureja hortensis Linnaeus. (25) (ND).
Satureja vulgaris (Linnaeus) Fritsch. (D).
Physalis subglabrata Mackenzie & Bush. (D).
Penstemon calycosus Small. (23) (L).
Chelone glabra Linnaeus. (23) (D, L).
Gratiola sphaerocarpa Elliott. (23, 31) (L).
Veronica arvensis Linnaeus. (23) (L).
Veronica serphyllifolia Linnaeus. (D).

Diodia teres Walter. (30, 31) (W).
Galium boreale var. *hyssopifolium* (Hoffman) DeCandolle. (D).
Galium boreale var. *intermedium* DeCandolle. (D).
Solidago hirtella (Greene) Bush. (18, 23) (L).
Solidago uniligulata var. *levipes* Fernald. (18) (B).
Eclipta alba (Linnaeus) Haskarl. (19, 31) (F).
Madia capitata Nuttall. (12) (F).
Coreopsis tripteris var. *deamii* Standley. (32) (D, F).
Coreopsis tripteris var. *intercedens* Standley. (32) (D, F).
Chrysanthemum balsamitae Linnaeus. (23) (L).
Hieracium longipilum Torrey. (19, 30, 31) (I).

Incorrect Reports from the Indiana Dunes

Polypodium virginianum. Lacks confirming specimens (26, 30).
Pteridium latiusculum var. *pseudocaudatum*. Referred to the typical form (30).
Thelypteris simulata. Referred to *T. palustris* Schott (2, 16, 30, 31).
Lycopodium clavatum. Lacks confirming specimens, northern (30, 31).
Lycopodium lucidulum var. *porophilum*. Referred to the typical form. (30).
Lycopodium obscurum. Referred to var. *dendroideum* Michaux (31).
Andropogon scoparius var. *frequens*. Referred to the typical form (30).
Andropogon scoparius var. *littoralis*. Referred to the typical form (5).
Andropogon scoparius var. *polyclados*. Referred to the typical form (30).
Andropogon scoparius var. *villosissimum*. Referred to the typical form (30).
Panicum barbulatum. Synonym of *P. dichotomum* Linnaeus (2, 30, 31).
Panicum depauperatum var. *psilophyllum*. Referred to the typical form (11).
Panicum huachucae var. *silvicola* and *P. tennesseense*. Referred to *P. lanuginosum* var. *fasciculatum* (Torrey) Fernald (2, 11, 23, 30, 31).
Panicum mattamuskeetense. Referred to *P. addisonii* Ashe (9, 11, 23, 25).
Aristida longespica. Referred to *A. intermedia* Lamson-Scribner (2, 11, 16, 30, 31).
Eragrostis caroliniana. Referred to *E. pectinacea* (Michaux) Nees (30).
Muhlenbergia sylvatica. Lacks confirming specimens (11, 31).
Sporobolus clandestinus. Lacks confirming specimens (11, 31).
Calamovilfa longifolia var. *magna*. Referred to the typical form (11, 23, 25, 30).
Poa trivialis. Lacks confirming specimens (30).
Agropyron biflorum. Referred to *A. subsecundum* (Link) Hitchcock (2, 11, 31).
Eleocharis ovata. Referred to *E. obtusa* (Willdenow) Schultes (30).
Rynchospora corniculata. Referred to *R. macrostachya* Torrey (2, 16, 31).
Rynchospora glomerata var. *paniculata*. Referred to the typical form (2, 31).
Eriophorum angustifolium var. *majus*. Referred to the typical form. (30).
Carex albicans. Referred to *C. varia* Muhlenberg (10).
Carex gracilescens and *C. heterosperma*. Referred to *C. laxiflora* Lamarck (23).
Carex hitchcockiana and *C. livida*. Lack confirming specimens (2, 31).
Carex stellulata var. *cephalantha*. Referred to the typical form (2, 31).

Commelina longicaulis. Referred to *C. angustifolia* Michaux (23).
Calla palustris. Lacks confirming specimens (3).
Juncus dichotomus and *J. setaceus*. Lack confirming specimens (2, 30, 31).
Allium sibiricum. Only a nonpersistent garden escape (25, 30).
Smilacina trifolia. Lacks confirming specimens (31).
Smilax glauca. Referred to *S. hispida* Muhlenberg (2, 14, 31).
Sisyrinchium campestre. Lacks confirming specimens (27).
Salix discolor var. *eriocephala*. Referred to the typical form (14, 23, 30).
Salix humilis var. *rigidiuscula*. Referred to the typical form (14, 30).
Salix interior var. *wheeleri*. Referred to the typical form (14, 30).
Salix sericea. Lacks confirming specimens (14, 31).
Betula lenta. Referred to *B. lutea* Michaux (2, 13, 31).
Betula populifolia. Lacks confirming specimens (13, 19).
Quercus minor and *Q. stellata*. Lack confirming specimens (2, 13, 28, 31).
Rheum rhaponticum. Only a nonpersistent garden escape (30).
Salsola kali. Referred to the var. *tenuifolia* Meyer (2, 31).
Stellaria graminea var. *latifolia*. Referred to the typical form (30).
Lychnis chalcedonica. Only a nonpersistent garden escape (30).
Sassafras albida var. *glauca*. Referred to *S. officinale* Nees (13, 29).
Draba brachycarpa. Referred to *D. reptans* (Willdenow) Fernald (30).
Draba caroliniana var. *micrantha*. Referred to the typical form (30).
Sisymbrium thalianum. Lacks confirming specimens (31).
Arabis virginica. Lacks confirming specimens (31).
Hamamelis virginianus var. *orbiculatus*. Referred to the typical form (14, 23, 30).
Mitella nuda. Referred to *M. diphylla* Linnaeus (2, 31).
Spiraea tomentosa var. *rosea*. Referred to the typical form (14, 30).
Amelanchier oblongifolia and *A. sanguinea*. Referred to *A. laevis* Wiegand, *A. humilis* Wiegand, *A. canadensis* (Linnaeus) Medicus, and their hybrids (14, 19, 30, 31).
Crataegus awaits a rational treatment of the genus.
Duchesne indica. Referred to *Rubus pubescens* Rafinesque (9, 12, 30).
Rosa blanda var. *glandulosa*. Referred to the typical form (30).
Rosa blanda var. *hispida*. Referred to the typical form (30).
Rosa carolina var. *glandulosa*. Referred to the typical form (30).
Rosa lyoni. Referred to *R. carolina* Linnaeus (14, 30).
Rosa rubifolia. Status undetermined (33).
Desmodium obtusum. Referred to *D. rigidum* (Elliot) DeCandolle (23).
Desmodium pauciflorum. Lacks confirming specimens, southern (30).
Lespedeza leptostachya. Lacks confirming specimens (30).
Ptelea trifoliata var. *mollis*. Referred to *P. t. deamiana* Nwl. (14, 30, 31).
Callitriche autumnalis. Referred to *C. heterophylla* Pursh (6, 8, 30).
Ilex glabra. Referred to *I. verticillata* (Linnaeus) Gray (14, 19).
Ilex verticillata var. *padifolia*. Referred to the typical form (14, 30).
Ilex verticillata var. *tenuifolia*. Referred to the typical form (14, 30).
Parthenocissus quinquefolia and var. *hirsuta*. Referred to *P. vitacea* (Knerr) Hitchcock (14, 30, 31).

Vitis rupestris. Referred to *V. vulpina* var. *syrticola* F. & W. (1, 3, 14).
Vitis cinerea. Referred to *V. labrusca* Linnaeus (2, 14, 16, 31).
Circaea intermedia. Lacks confirming specimens (2, 30, 31).
Cornus asperifolia. Lacks confirming specimens (14, 31).
Nyssa sylvatica var. *biflora*. Referred to the typical form (2, 13, 16, 31).
Vaccinium corymbosum var. *glabrum*. Referred to the typical form (14, 30).
Acerates viridiflora var. *lanceolata*. Referred to the typical form (23, 30).
Cuscuta gronovii var. *vulgivaga*. Referred to the typical form (23).
Cynoglossum boreale. Lacks confirming specimens (30).
Lappula redowskii var. *occidentalis*. Referred to *L. echinata* Gilibert (7).
Gerardia pedicularia. Referred to the var. *ambigens* Fernald (2, 16, 31).
Viburnum cassinoides and *V. dentatum*. Referred to *V. affine* Bush and var. *hypomalacum* Blake (2, 14, 19, 30, 31).
Cucurbita pepo var. *ovifera*. Only a nonpersistent garden escape (30).
Lobelia puberula. Lacks confirming specimens, southern (2, 31).
Vernonia altissima. Referred to *V. missurica* Rafinesque and *V. fasciculata* Michaux (2, 16, 30, 31).
Liatris pycnostachya. Lacks confirming specimens, western (2, 30, 31).
Solidago arguta, S. aspera, and *S. bicolor*. Lack confirming specimens (2, 16, 18, 30, 31).
Solidago juncea var. *scabrella*. Referred tc the typical form (18, 30).
Aster divaricatus. Referred to *A. furcatus* Linnaeus (30).
Aster lateriflorus var. *glomerellus*. Referred to the typical form (30).
Aster macrophyllus var. *pinguifolius*. Referred to the typical form (30).
Aster tradescanti var. *foliosus*. Referred to the typical form (30).
Helianthus atrorubens. Lacks confirming specimens, southern (30).
Coreopsis major. Lacks confirming specimens, southern (2, 31).
Artemisia longifolia. Lacks confirming specimens (30, 31).
Hieracium marianum. Referred to *H. gronovii* Linnaeus and *H. scabrum* Michaux (2, 16, 31).

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Notes and Discussion

THE IDENTITY OF PRUNUS LANATA M. & B.

BENJAMIN FRANKLIN BUSH

When Mackenzie and Bush described their *Prunus lanata* in 1903, they thought they were basing the new species on Sudworth's *P. americana lanata*, a very common tree of western Missouri and eastern Kansas. Having but little experience in nomenclature, these authors erred in taking up Sudworth's varietal name *lanata*, as did other writers, like Sargent, Sudworth, Wright and Hedrick.

Sudworth applied the new name *lanata* in 1897, basing it on Torrey and Gray's *P. americana mollis*, described in 1840. *Americana mollis* was described from soft-leaved specimens collected at the same place and same time as *P. nigra*, and these have been shown to belong to that species.

Sargent accepts *P. lanata* M. and B., in his Manual 1922, and quotes as a synonym *P. americana lanata* Sudw., but overlooks the fact that Sudworth's variety *lanata* was based on *P. americana mollis* T. and G., Sargent gives as the range for *P. lanata* southern Indiana, southern Illinois, western Kentucky, Missouri, Arkansas, Louisiana, Oklahoma and Texas, but omits New York, the type-locality of *P. americana mollis*, and consequently the same for *P. americana lanata* Sudw.

Rydberg accepts *P. lanata* M. and B. in his Flora of the Plains, and cites *P. americana mollis* as a synonym, but overlooks the fact that Torrey and Gray's variety *mollis* came from the same locality as *P. nigra* in New York, since he cites Illinois, Iowa, Texas and Missouri as its range, and again omits New York.

Small in his Manual of the Southeastern Flora (1933) does not accept *P. lanata* M. and B. as a species, but refers it to *P. americana lanata* Sudw., which he states ranges from New York to Colorado, Montana and Florida. No mention is made of the middle states.

If *Prunus lanata* M. and B. is the same as *P. americana mollis* T. and G., the known range of *P. lanata* should be given as New York to Kentucky, Texas and Colorado, but if *P. lanata* M. and B. is not *P. americana mollis* (and I am very sure it is not), writers should cease citing the latter as a synonym of *P. lanata* M. and B.

COURTNEY, MISSOURI.

Book Reviews

BEFORE THE DAWN OF HISTORY, by Charles R. Knight. New York: Whittlesey House, 1935. xii + 119 pp. $2.50.

Charles R. Knight's latest and best restorations of vertebrates and plants are mural paintings, some of which are substantial contributions to paleoecology. This volume, whose pages measure 9 by 12 inches, assembles these restorations and provides them with simple explanatory text and introduction. Subjects range from pre-Cambrian algae to Pleistocene conifers; from cephalopods to mammals, with reproduction of such quality as to permit detailed examination where it is required. For those who find difficulty in visualizing sizes, there is a page of sketches showing, to scale, varied types of living and fossil organisms, while biologic readers are provided with a geologic time scale.

Well printed and beautifully bound, the book will be of value in college as well as public libraries, and to those readers whose ideas of fossil animals have been gained too largely from the "outlines" of Thomson and Wells, or the breathless text of J. H. Bradley. It distinctly is the best popular volume on paleontology now available in English. — C. L. FENTON.

AMERICAN BIRD BIOGRAPHIES, by Arthur A. Allen. Ithaca: Comstock Publishing Co., 1934. ix + 238 pp. $3.50.

The life histories of twenty familiar birds, presented in popular, autobiographical form. They represent an exhaustive review of literature as well as Dr. Allen's own observations, and so are far more detailed than the familiar "nature story" which they superficially resemble. Their appeal, therefore, is to both the naturalist and the popular reader; the latter will be specially intrigued by the many excellent photographs and the twenty wash and color drawings by G. M. Sutton. Several of these are, from an artistic viewpoint, the best bird portraits that have appeared in America.

It is unfortunate that the wide printed page will discourage juvenile readers, and is unpleasant even to the adult eye.—C. L. FENTON.

THE BOTANICAL REVIEW interpreting botanical progress. Editors and publishers: H. A. Gleason and E. H. Fulling. Published monthly at Lancaster, Pa. $3.00 per year.

This is, strictly speaking, the first botanical reviewing magazine in the English language. Nor has it any predecessors in any language considering its differences from Lotsy's *Progressus rei botanicae* and Wettstein's *Fortschritte der Botanik*. The editors reserve the right to ask for contributions rather than assign specific fields to permanent collaborators. The preliminary announcement inviting subscriptions contained a notable list of proposed papers by carefully chosen specialists. So far two numbers have made their appearance and in general they seem to fulfill one's best expectations. The type of contribution is well known in German magazines as "Sammelreferat" and consists in presenting a digest of the literature pertaining to particular topics with critical annotations by the reviewers.

Botanists will show their appreciation best by entering their subscriptions and thus materially supporting an undertaking needed in these times of intense specialization. It is sincerely hoped that they will display such interest for the common good of all research students and the many who have no access to libraries or who experience difficulties with foreign languages. If it should be possible to increase the size and scope of this publication through whole-hearted support we would all gain by being informed of advances made in the different fields of botanical investigation.—TH. JUST.

PHYTOGRAPHY AS A FINE ART comprising Linnean description, micrography and penportraits, by Dr. J. W. Moll. Leyden, E. J. Brill, 1934. xx + 534 pp., 7pls., gr. 8vo. 15 guilders.

Dedicated to the memory of Alphonse de Candolle whose book *La Phytographie* inspired it, the present work not only continues that tradition in phytographical methods in organography but applies the same to histology and cytology. It appeared posthumously, Professor Moll having died in 1933. He had reached the venerable age of 82 but had unfortunately become blind and hard of hearing. A considerable part of his life had been devoted to the perfection of this work which was already in the hands of the publisher at the time of his death. Professor J. C. Schoute, his able successor at the University of Groningen, is largely responsible for such revisions and alterations as were deemed necessary. In fact Prof. Schoute not only revised the final manuscript but also contributed certain sections, i.e. phyllotaxy (pp. 150-153).

It is hoped that attention to this work will not be exclusively taxonomic since botanists of other interests will find it exigent of more than merely desultory and perfunctory reading. In a certain sense the recommendations made by the author point towards an ideal condition rarely achieved and perhaps far beyond the present standard objectives of teaching. This novel contribution with its invaluable amount of information may be regarded as Prof. Moll's scientific legacy to the botanical world.—TH. JUST.

ZUR ÖKOLOGIE DER SALZMARSCHEN DER NORDÖSTLICHEN VEREINIGTEN STAATEN VON NORDAMERIKA. (Die osmotischen Verhältnisse des Bodens als Standortsfaktor. Die Ökologie der osmotischen Werte und der Zellsaftchemie bei Halophyten). Von Maximilian Steiner. Jahrbücher für wissenschaftliche Botanik **81**(1): 94-202, 59 figs. 1934.

Exact knowledge regarding the ecology of halophytes is of fairly recent date since Schimper's view were refuted by modern experimental studies. The present paper is the outcome of work carried out in the salt marshes of Connecticut, while the author was holding a fellowship at Yale University in 1933.

Two sets of problems were pursued. The first of these pertains to the soil and its properties with reference to the vegetation it bears. The concentration of the soil solution is considered as the most important habitat factor. It may vary within very small areas thus directly affecting the composition of the vegetation. These differences were also noted in soil profiles which were correlated with the structure of the root systems of the most important plants in the marshes. Furthermore changes due to climate and tides were recorded from several selected stations. The osmotic component of the suction tension of the soil is here considered as of great significance because of the high water content of the soil in the marshes. Evaporation from the surface layer of the soil is, to a considerable degree, prevented by the vegetation which thus contributes towards the maintenance of favorable environmental conditions. *Salicornia europaea* was selected as the type to trace the significance of the osmotic value of the soil solution as a limiting factor. If the concentration is very high degenerate forms appear. If it further increases death of the plant results. Optimal development, however, depends on a certain intensity of the relative light requirement. Otherwise degenerated shade plants result.

The second group of problems relates to the osmotic values and chemical composition of the cell sap of halophytes. The highest osmotic values occur in xeric-halic zones. The spectra of osmotic values for the different types of communities are very instructive. An increase in osmotic value depends largely upon an increase of the amount of easily soluble salts (especially chlorides) at least as far as the euhalophytes are concerned. Variations of the osmotic value in the same species from localities with different salinity are much lower than the differences in the soil concentration and may in almost all cases be traced to an increase of the salt concentration in the cell sap. Osmotic changes due to seasonal variations are minor and appear parallel with changes of the concentration of the soil solution caused by climatic conditions. *Juncus Gerardi* is the only species showing a constant increase of the salt concentration and thus of the osmotic value of the cell sap. The even course of the osmotic curve of succulent halophytes is explained by the increase of the water content due to age while most of the other salt marsh plants regulate their osmotic value by the active excretion of superfluous salt. This "Absalztypus" (Stocker) plays a dominant rôle in the composition of the salt marsh vegetation in America. According to a careful estimate, about 80-90% of the whole vegetation of the salt marshes may be considered as belonging to this type. Apparently minor quantities of salts are continually carried by the transpiration stream and thereby reach the transpiring organs. However this problem has not been solved. According to the mode of osmotic regulation three types of halophytes may be recognized in the salt marshes: 1) succulent: regulation is accomplished by increase of the solvent; 2) salt excreting: regulation by excretion of superfluous salts; 3) *Juncus Gerardi:* no such regulatory mechanism. Salt content and osmotic value increase continually. Studies in the daily course of osmotic value illustrate clearly the differences between 1 and 2.

This outline, largely taken from the author's summary, shows the multitude of problems studied and some of the highly interesting results obtained. Ecologists will find this highly original contribution a most valuable addition to their present knowledge of so complex a group of organisms and environmental conditions as are met in the salt marshes on the Atlantic coast.—Th. Just.